43d Congress, 1st Session. | HOUSE OF REPRESENTATIVES. | Ex. Doc. No. 208.

EXTENSION OF THE CHESAPEAKE AND OHIO CANAL TO THE OHIO RIVER.

LETTER

FROM

THE SECRETARY OF WAR,

IN ANSWER TO

A resolution of the House of March 20, 1874, *transmitting, in compliance with the act of March* 3, 1873, *a report upon an examination of waters for the extension of the Chesapeake and Ohio Canal to the Ohio River.*

April 14, 1874.—Referred to the Committee on Railways and Canals and ordered to be printed.

War Department, *April* 3, 1874.

The Secretary of War has the honor to transmit to the House of Representatives, in compliance with House resolution of the 31st ultimo, copy of report, dated March 20, 1874, from Maj. W. E. Merrill, Corps of Engineers, upon an examination of waters for the extension of the Chesapeake and Ohio Canal to the Ohio River, made in compliance with the second section of act of March 3, 1873.

WM. W. BELKNAP,
Secretary of War.

Office of the Chief of Engineers,
Washington, D. C., April 1, 1874.

Sir: I have the honor to transmit herewith a copy of a report received from Maj. Wm. E. Merrill, Corps of Engineers, upon an exploration of waters for the extension of the Chesapeake and Ohio Canal to the Ohio River, made in compliance with second section of act of March 3, 1873, making appropriations for certain public works on rivers and harbors.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. W. W. Belknap,
Secretary of War.

EXTENSION OF THE CHESAPEAKE AND OHIO CANAL TO THE OHIO RIVER.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, March 20, 1874.

GENERAL: The act of Congress approved March 3, 1873, making appropriations for rivers and harbors contained the following clause: "And not to exceed $5,000 of the above appropriation may be expended in an exploration of routes for the extension of the Chesapeake and Ohio Canal to the Ohio River by the north and south branches of the Potomac River."

The duty of making this exploration having been assigned to me, and being unable, on account of my other duties, to make the survey in person, I considered myself fortunate in being able to put it in charge of Col. Thomas S. Sedgwick, late of the volunteer service, who had served under my command in the earlier years of the late war. His report is herewith forwarded.

The idea that there ought to be a canal from tide-water to the Ohio, via the valley of the Potomac, is a very old one, and was a favorite scheme of Washington, who was a stockholder in the Potomac Company, an organization that began work by attempting to improve the channel of the Potomac. Their efforts, however, were abortive, and the project slumbered until it was revived in 1824, under the auspices of the National Government. During this year, and 1825 and 1826, very careful surveys were made along the entire line of the proposed canal from Washington to Pittsburgh, special care being given to the manner of crossing the mountains. The results of these investigations are given in the copies of the Reports of the Board of Internal Improvements, which are herewith attached as Appendix A.

The object of the surveys of fifty years ago was to discover a practicable water-route between the Potomac and the Ohio. As the eastern division of the proposed canal (that portion lying in the valley of the Potomac) has been built as far as Cumberland, I inferred that my duty was to ascertain how to extend this canal toward the Ohio. The act itself required the survey to be made "by the north and south branches of the Potomac." As the limited sum at my disposal made it impracticable to run more than one instrumental line, and as the south branch of the Potomac enters the main river seventeen miles below the present head of the canal, and flows from a direction almost at right angles to the general line of canal, if Pittsburgh be considered as its objective point, I decided to restrict the examination to the north branch of the Potomac. Mr. Benjamin Latrobe, late chief engineer of the Baltimore and Ohio Railroad Company, very kindly placed at the service of Colonel Sedgwick all of the information which he had acquired while surveying to ascertain the best route for a railroad over the mountains, and gave it as decidedly his opinion that it was useless to seek, south of the Baltimore and Ohio Railroad, for a pass through which to carry a canal whose western terminus was designed to be at Pittsburgh. If there were an intention of making a connection with the proposed James River and Kanawha Canal, then the valley of the south branch of the Potomac should be surveyed, but inasmuch as I could hear of no such intention among those interested in the extension of the Chesapeake and Ohio Canal, and as such a canal, even if built, would probably be unable to divert any through traffic from the shorter and easier line down the James River, I concluded to abandon the

south branch entirely. This survey was therefore restricted to a line via the north branch of the Potomac.

The Board of Internal Improvements, in 1825, reported a feasible route via North Branch, Savage River, Crabtree Creek, Deep Creek, and the Youghiogheny. In 1826 they reported a much better route, at a lower elevation, by way of Wills Creek, Flaugherty's Creek, and Casselman's River to its junction with the Youghiogheny and the other canal line. The route over the mountains, which Colonel Sedgwick selected for examination, was intermediate between these two. Commencing at Cumberland, it followed the North Branch, Savage River, and Blue Lick, and then, by a tunnel, struck Casselman's River at the Plucher reservoir of the Wills Creek route; thence it followed down the Casselman until it joined the Wills Creek route at the mouth of Flaugherty. The details of these three routes are given in the accompanying documents. The following is a tabulated statement of the more important features of the three routes between Cumberland and the mouth of Casselman. The route recently surveyed is called, for distinction, the Savage River and Blue Lick route.

Comparison of lines for crossing the mountains.

Routes and dimensions.	Deep Creek route.	Wills Creek route.	Savage River and Blue Lick route.
Length from Cumberland to mouth of Casselman ....miles..	88.59	70.57	100
Length of tunnel at summit..miles..	1.33	4.05	5
Elevation of summit tunnel above tide ....feet..	2,408	1,972	2,100
Lockage from Cumberland to tunnel......................................feet..	1,804	1,368	1,496
Lockage from tunnel to mouth of Casselman ....feet..	1,070.5	634.5	762.5
Total lockage between tunnel and mouth of Casselman............feet..	2,874.5	2,002.5	2,258.5
Length of summit feeders...miles..	12.0	6.0	0.1

In preparing the above table it became necessary to determine the elevation above tide of the Cumberland bench-mark. The surveys of 1828, and the construction of the canal, showed that there was an error of 69 feet in the levels of the eastern section of the canal as surveyed under the direction of the board of internal improvements. The bottom of the canal at Cumberland is 603.75 above tide, and its surface 609.75. The Government bench-mark was found to be at the elevation of 632.27 above tide. An error in leveling was also found between Cumberland and the Wills Creek tunnel. As the latest survey put this tunnel definitely at 1,972 above tide, that height has been considered as established, and the Deep Creek tunnel has been placed 436 higher, according to the relative difference of level found by the board of internal improvements. The lockages up to the three tunnels have been calculated from the present level of the canal at Cumberland.

A slight examination of the above table shows that the Wills Creek route is greatly superior to the other two, being shorter than either of the others, and having a much lower summit-level. It is eighteen miles shorter than the Deep Creek route, and has 872 feet less lockage, which is equivalent to dispensing with 109 locks. It has a longer tunnel, but this disadvantage is more than counterbalanced by the other great advantages. As compared with the Savage River and Blue Lick route (the new route surveyed by Colonel Sedgwick) it is twenty-nine and a half miles shorter, has 256 feet less lockage, and its summit-tunnel is one mile shorter. It is, therefore, a better route in every respect. Com-

paring the Deep Creek route with that by Savage River and Blue Lick we find that the former is eleven miles shorter and has a much shorter summit-tunnel, but has 616 feet more lockage. As far as time of transit is concerned we may assume that eight minutes are required at each lock for passing a boat through, which is equivalent to one minute for each foot of lift. The 616 feet of extra lockage would therefore require six hundred and sixteen minutes, or ten hours and sixteen minutes, during which time a boat could travel thirty-one miles on a level. As far, therefore, as speed of passage is concerned, the new route is twenty miles shorter in distance, or six hours and forty minutes quicker in time, than the Deep Creek route.

But there is always difficulty in maintaining enough water for navigation in very short levels, and therefore it is very desirable to have the locks as far apart as possible. Both of the last-mentioned routes follow the same line going west as far as the mouth of Crab-Tree, and therefore we need only compare them west of this point. On the Deep Creek route the heads of the locks would be at an average distance apart of 351 feet, but the board state that "this is on the supposition of a uniform declivity, which is far from being the case, and more especially in the valley of Crab-Tree Creek, where, toward the head, the locks on account of the steepness of the ascent could not even find room, unless their lift should be considerably increased. To this difficulty we must add the narrowness of the valley, which would oblige to resort to very expensive means to erect, where necessary, double sets of locks, as also to shelter the work from destruction either by high freshets or by heavy showers."

On the Savage River and Blue Lick route the average distance between the heads of locks from the mouth of Crab-Tree to the eastern portal of the tunnel is 651 feet, and there is no difficulty in preserving this average throughout this part of the line. This is a very great advantage. Another advantage is that the new route, immediately after crossing the summit, enters a rich coal-basin (the Salisbury) on the other side of the mountains. As far as known the country on the Deep Creek route, between the mouths of Crab-Tree Creek and Casselman River, has no mineral resources and would furnish but little business to the canal.

If, therefore, a choice were necessary between the Deep Creek and the Savage River and Blue Lick routes, I think that the preference should be given to the latter, although it is proper to state that the long summit-tunnel will cause detentions that will appreciably reduce the gain in time over the Deep Creek route.

An inspection of the map shows that the only other possible route for a canal between Cumberland and Pittsburgh besides those already examined is by way of the North Branch to its head, and thence across the mountains to the Cheat River. To this route there are several objections.

1. The approximate height of the head-waters of the North Branch at Fairfax Stone (as shown by Colonel Sedgwick's reconnaissance) is 2,520 feet above tide, showing that a tunnel in this vicinity would have a greater elevation than on any other line, and that, therefore, this line would require a much greater number of locks.

2. If the canal did not turn off before reaching the head-spring it could not be supplied with water.

3. A route by the North Branch and Cheat River would be greatly longer than by any other line.

4. The Cheat River is an exceptionally wild and difficult stream, and

the maintenance of a canal alongside of it would be very difficult and costly. (For a description of Cheat River see Appendix A, page 132.)

5. Along this line the country is very sparsely settled, and there would be but little business for a canal.

Any route passing south of the North Branch would be still more objectionable.

We therefore conclude that, in extending the Chesapeake and Ohio Canal, the choice of routes is absolutely limited to the three mentioned above. In order of desirability they are as follows:

1. Wills Creek route.
2. Savage River and Blue Lick route.
3. The Deep Creek route.

As, by the appropriation act, I was debarred from having an instrumental examination made of the Wills Creek route, my knowledge of it is limited to the older surveys, and what could be seen while passing over the railroad between Cumberland and Pittsburgh, which, except at the summit, occupies throughout its whole length the location chosen for the canal. The valley of the Little Wills Creek is so narrow and so wild that it is doubtful if the railroad has left room for a canal; but this route is so greatly superior to any other, that, in my opinion, no work should be done toward extending the canal until a very careful examination is made of this line, to ascertain if it is still practicable for a canal. As far as the Salisbury coal-basin is concerned, it could more readily be reached by the Wills Creek route (if the feeder from Plencher's were made navigable) than by the Savage River and Blue Lick route, as the distance from Salisbury to Cumberland via Wills Creek is forty-three miles, while by the Savage River it is fifty-seven.

But a canal by any of these routes is so very costly that local advantages must be entirely subordinated to the principal object of the expenditure. In this case a connection between the Potomac and the Ohio is the evident solution desired, and therefore the line chosen for the canal should be such as will give the most useful connection, regardless of local interests.

After crossing the mountains the next question is, how to descend the valley of the Youghiogheny. No instrumental survey could be made of this part of the route, but enough was visible from the cars to indicate that there would be considerable difficulty in this valley, especially at Ohio Pile Falls. The route recommended by the board of internal improvements has been occupied by the railroad from Cumberland to Pittsburgh, and an effort must be made to find room for the canal on the other side of the river. I would, therefore, recommend an appropriation for this purpose.

In order to test the value of Colonel Sedgwick's estimate of the cost of the summit-tunnel, I applied to the authorities of the Baltimore and Ohio Railroad for a statement of the cost of the Sand-Patch tunnel, which is at about the same place, though at a higher elevation, as the proposed Wills Creek tunnel. Mr. Latrobe very kindly gave me full particulars, and, with his consent, I append his letter as Appendix C. This tunnel, 4,800 feet long, cost $420,000, or at the rate of $87.50 per running foot for tunnel and approaches. The section, in the clear, of the Sand-Patch tunnel is 16 by 18½, while that of the proposed canal-tunnel will be a segment, 26 feet in height, cut from a circle whose radius is 16 feet. The area of excavation for the Sand-Patch tunnel is therefore about 330 square feet, and that of the proposed canal-tunnel about 800 square feet. The latter is, therefore, two and four-tenths larger than the railroad-tunnel.

Colonel Sedgwick places the cost of his five-mile tunnel at $8,346,000, which is at the rate of $1,669,200 per mile, or $316 per running foot. At this rate a tunnel of the sectional area of the Sand-Patch tunnel would cost $132 per running foot, which is 51 per cent. more per running foot than the latter tunnel actually did cost. A wide tunnel is less costly per cubic yard than a narrow one; but, on the other hand, a long tunnel is more costly than a short one. In the absence of any definite knowledge of the depth of shafts, or of the stratification of the rock through which the five-mile tunnel is to pass, we may content ourselves with the above estimate as reasonably accurate.

As corroborative evidence that this estimate is not too small, I would state that the published estimate of the cost of the summit-tunnel on the James River and Kanawha line, 7.8 miles long, is $13,253,310. This last tunnel has a section of 52 by 34½ feet, being 46 feet wide at water-line and 7 feet deep. It is, therefore, about 70 per cent. larger than the tunnel proposed by Colonel Sedgwick.

WESTERN TERMINUS OF CANAL.

At present there is slack-water on the Monongahela to and above the mouth of the Youghiogheny. The terminus of the canal should be at this slack-water. An effort is being made to slack-water the Youghiogheny to West Newton, or higher, for the benefit of the coal-mines on this river. Although this may answer the wants of coal operators, who can only ship coal when there is a sufficiency of water in the Ohio, at which time there is usually good water in the tributaries, it cannot be depended on as the terminus of a canal doing a large business. The Youghiogheny, in dry seasons, does not supply enough water to provide lockage for an extensive navigation, and there is sometimes trouble even on the Monongahela. The terminus of the Chesapeake and Ohio Canal should therefore be at McKeesport.

As Colonel Sedgwick has stopped his estimate at Connellsville, it is necessary to increase it by the cost of extending the canal to McKeesport. The distance from Connellsville to McKeesport is forty-four miles, and the lockage in this distance is put by the board at 152 feet. In continuing the canal to Pittsburgh they have an additional lockage of thirty-five feet. As their canal was assumed to be 5 feet in depth, and as all their levels refer to the bottom of the canal, the latter must have been taken at McKeesport at an elevation of 30 feet above low water in the Ohio at Pittsburgh. Between Pittsburgh and McKeesport there are two dams across the Monongahela, each of which has a lift of 8 feet. The bottom of the canal at McKeesport must therefore be 14 feet above the surface of the Monongahela at the same place, and the lockage to be provided for must be 19 feet. The increase in length of canal over Colonel Sedgwick's estimate will therefore be forty-four miles, and the increase in lockage 171 feet.

The board's estimate of cost from Connellsville to McKeesport was $2,047,996. Increasing this by 25 per cent. it becomes $2,559,995, and adding the cost of the three additional locks ($45,000 more,) we find the total cost of this section $2,605,000. If we allow 10 per cent. for contingencies the estimate becomes $2,865,500. This would make Colonel Sedgwick's total estimate for a canal, 33 feet wide at bottom, 48 feet wide at water-line, and 5 feet deep, and extending from Cumberland, Md., to McKeesport, Pa., a distance of 171½ miles, $23,133,585.

SIZE OF CANAL.

The depth which Colonel Sedgwick has chosen for the canal seems to me to be inadequate to the wants of a great through water-route. I think that on no account should the extension have a less size than the canal as now built to Cumberland; otherwise the sums expended below Cumberland in providing 6 feet of water will have been wasted as far as through-traffic is concerned. The chief objection to increasing the depth of the canal comes from the increased supply of water required to keep up the levels. The increased waste in a deep canal is due to the increased filtration through the soil, and the increased leakage through gates, both of which increases are due to the greater pressure exerted by the deeper water. If the calculations of those who examined and reported on the water-supply are to be trusted, there certainly seems to be enough water available to supply a 6-foot canal, if made reasonably tight.

There seems to be no doubt that a 6-foot canal can be kept up throughout all but the summit-level without any unusual expense. If, then, special care be taken in the construction of the summit-level, so that a 6-foot canal shall hold water as well as a 5-foot one usually does, there will be no lack of water, and a slight increase in expenditure will insure a far greater increase in the usefulness of the work. If the canal can only give 5 feet depth of water its utility will hardly be sufficient to justify its construction.

The only survey which we could make was so hurried, and the quantities to be used in calculation so uncertain, that it seems hardly worth while to attempt to estimate in detail how much the estimate should be increased to provide for a 6-foot extension. If a section were assumed the same as that of the present canal at Cumberland, the water area would be increased from 202½ square feet (as assumed by the board for a 5-foot canal) to 252 square feet. This is an increase of 24½ per cent. Therefore, roughly assuming a corresponding increase of expenditure, we find the cost of a canal 30 feet wide at bottom, 54 feet wide at water-line, 6 feet deep, and extending from Cumberland to McKeesport, one hundred and seventy-one and one-half miles, $28,801,313. I think that this estimate is as fair an approximation as our limited information will now permit.

WORKING OF SUMMIT-TUNNEL.

I am decidedly of the opinion that the summit-tunnel should be worked by steam. The summit-tunnel on the Burgundy Canal in France is successfully operated by steam-tugs, towing by the use of a submerged cable. They work very economically, and in fact this system is very generally used in France on their canalized rivers. To avoid smoke, which would be very objectionable in very long tunnels, it might be practicable to carry large reservoirs of steam, supplied from boilers at each end of the tunnel, as I understand is now done in New Orleans on one of the street-car lines. The omission of the tow-path saves a very considerable sum in the cost of the tunnel, and even in case of accident to a tug there would be no difficulty in poling the boats out of the tunnel.

INCLINED PLANES.

Where locks have to be so close together, as will undoubtedly be necessary at many places on this extension, I think that it would be in every way advantageous to resort to the system of inclined planes so

successfully used on the Morris and Essex Canal. I am informed that, by this system, boats travel up and down the inclines as fast as they do on a level, and thus one of the greatest objections to a heavy amount of lockage is entirely obviated. Colonel Sedgewick has nearly finished a paper on this subject, which I will forward when completed, and which I request may subsequently be attached to this report. If the Wills-Creek route should prove to be still available, I believe that its heavy ascending grade going west will make it necessary to use inclines instead of locks, at least immediately east of the summit. Boats would have to be in two parts to accommodate themselves to this arrangement. There are probably other places on the line where the same construction would be useful.

WESTERN CONNECTIONS.

It must be borne in mind that both this canal and the James River and Kanawha will utterly fail to become great through-routes of water transportation to the seaboard, unless the Ohio River is made to give a depth of at least 6 feet throughout the summer and fall, the time when the canals are doing their heaviest business, but the rivers are at their lowest. It is foreign to the present report to do more than allude to this matter, but as it is a vital one I think it proper, as the engineer in charge of the Ohio, to state that there is no practical difficulty in the way of securing this depth throughout the year by movable dams. For details reference is made to Ex. Doc. No. 127, House of Representatives, Forty-third Congress, first session. I have no hesitation in saying that it is impracticable to secure such a depth for navigation, at least above the falls, by any attempted guiding and controlling of the natural currents, however simple such operations may appear in the office. They have been repeatedly tried and found wanting. Below Pittsburgh the Ohio is often down to 12 inches, and between Louisville and Cairo it is not unfrequently down to 20 inches. For a fuller statement on the practicability of improving the navigation of the Ohio below the falls see Ex. Doc. 127, Part 3, House of Representatives, Forty-third Congress, first session.

COMMERCIAL ADVANTAGES OF THIS CANAL.

This is a matter that I thought of working up, and for that purpose I had some statistics prepared from the last census-tables, but I have concluded that until a definite line of canal is selected, and a fair approximation of its cost is made, it will not be practicable to make a useful comparison with other through-routes. Until the profile of the canal is determined its equated length cannot be obtained, and this alone gives a basis of comparison. If this investigation is continued I will endeavor in my next report (should the survey be again confided to me) to take up this branch of the subject. In order to have a graphic comparison between this water-line, the Erie and the James River and Kanawha, I have prepared a profile-sheet which shows each line. They all end at tide-water, the Erie beginning at Buffalo, the Chesapeake and Ohio at Pittsburgh, and the James River and Kanawha at Point Pleasant. The profiles show very clearly the immense natural advantages of the route occupied by the Erie Canal.

CONCLUSION.

In concluding this report I would recommend, as I have mentioned before, that if this investigation is to be continued careful surveys should be made by the Will's Creek route from Cumberland to McKeesport. This would require three independent parties under the control of one chief. One party should take the line from Cumberland to Meyer's

Mills, and the other two should divide the distance from Meyer's Mills to Connellsville. From the latter place to McKeesport the route is unquestionably feasible, and the old surveys will do until the work of construction on the mountain section is well under way. The entire route should be surveyed with a special view to the use of inclined planes on difficult ground, and to the location of the necessary reservoirs, for reservoirs will be needed along the whole of the line. I would not recommend any survey at present of the Savage River route. It will be time enough to take that up if it is found impracticable to get a line through by way of Will's Creek. A saving in distance of twenty-nine and a half miles, and in lockage of 256 feet, is equivalent to a saving in time of about fourteen hours, which is so great a gain as to justify a large increase of expenditure in order to secure it. The cost of the surveys recommended would be about $20,000, and this appropriation I would recommend if this extension is to be carried through.

Respectfully submitted.

WM. E. MERRILL,
Major Engineers.

General A. A. HUMPHREYS,
Chief of Engineers.

MR. T. S. SEDGWICK'S REPORT.

WASHINGTON, D. C., *January* 30, 1874.

Col. WILLIAM E. MERILL,
United States Engineers, in charge Surveys and Explorations for the Extension of the Chesapeake and Ohio Canal:

COLONEL: I have the honor to make the following report of instrumental reconnaissance and examinations for the extension of the Chesapeake and Ohio Canal.

The western terminus of the canal is at Cumberland, Md., and the problem of its extension is a difficult one, arising not only from the great elevation to be overcome and the steep eastern slope of the Alleghany Mountains to be climbed, but also from the changed condition controlling the extension now as compared with those existing when the construction of the canal was begun in 1828. The route by Will's Creek and Flaugherty Creek to Meyer's Mills, on Castleman River, and thence by Castleman River and the Youghiogheny and Monongahela rivers to Pittsburgh, then believed, and, in fact, fully demonstrated to be the best and most practicable route between Cumberland and Pittsburgh, is now occupied and controlled throughout its entire length by the Pittsburgh branch of the Baltimore and Ohio Railroad; so that portion of the route between Cumberland and the summit of the mountain at Sand-Patch tunnel is not now practicable for the location and construction of a canal, there being also a second railroad (the Pennsylvania and Cumberland) between Cumberland and the mouth of Little Will's Creek, fifteen miles, so that the hope of the extension of the canal reasonably reverts to the Deep Creek route, the alternative route with the Will's Creek route, both which were reported on in detail by the board of internal improvements in 1826.

This route follows the North Branch of the Potomac to the mouth of Savage River, and thence by the Savage River and Crabtree Creek to Bear Creek and Deep Creek, and by the Youghiogheny to the junction with Castleman River, at Turkey-Foot, now confluence, a point common to the two routes.

This route is eighteen miles longer than the Will's Creek route, and its summit-level was taken 440 feet higher than the summit-level of the Will's Creek route. That portion of the route between Cumberland and the mouth of Savage River is occupied in general by the main line of the Baltimore and Ohio Railroad, but the valley being wide and open, and the railroad company having been directed by process of law to respect the prior location of the canal, which had been made as far as the mouth of Savage River, the conditions are not materially changed with regard to the location and construction of a canal between those places, excepting, probably, in the matter of land and right of way.

The favorable condition of the Will's Creek route being so disadvantageously modified by railroad occupation, the question arose as to the probability of the existence of a route between the Will's Creek and Deep Creek routes, which could have a lower

summit-level than the Deep Creek route, and which could be supplied with water from the reservoirs on Castleman River designed for the Will's Creek route, and at the same time would have a summit-tunnel of a feasible length. In accordance with these considerations it was deemed advisable, with your approval, to thoroughly examine the summit-passes between the Savage and Castleman Rivers, a region not heretofore surveyed, and to determine their character and conditions with reference to the extension of the canal thereby. Accordingly a route, beginning at the mouth of Savage River, the termination of the previous surveys, and following the Savage to Blue Lick Run, crossing the summit of the mountains near the Shades on the Old National road, and descending to the Castleman River, at Salisbury, Va., by Piney Run, was examined by instrumental survey.

This route was found to be generally favorable, especially as to the matter of a good location and cost of construction of a line of canal, though not so favorable as to the summit-tunnel. It traverses a very important and valuable coal-basin, and would provide an additional transportation outlet for the Cumberland coal-basin and enhance the agricultural growth of the valley of the North Branch and its larger tributaries. This route is longer than the Will's Creek route, but is better conditioned as to the distribution of locks, and efficiency and economy of the water-supply.

THE CONDUCT OF THE SURVEY AND CHARACTERISTIC FEATURES OF THE ROUTE.

The surveying party rendezvoused at Bloomington, W. Va., near the mouth of Savage River, on the 25th of July, but owing to some delay in procuring a cook, and the slow arrival of the surveying instruments, surveying operations were not begun until August 1. The survey was begun at the junction of Savage River and the North Branch, which comes some forty miles from the southwest, runs northeasterly some thirty miles to Cumberland.

The elevation was taken to be 960 feet above tide-water at Georgetown, D. C., as determined by the surveys of 1828. This elevation corresponds with the grade notes of the Baltimore and Ohio Railroad.

The Savage River from its mouth to Crabtree Creek, five and a quarter miles, has a general direction west-northwest, its bed rising uniformly at the rate of 74 feet per mile. In this distance it has worn its way through and right across the axis of Savage Mountain (which lies northeast and southwest) to a depth of nearly 1,000 feet, consequently the channel is crooked, and has rough, rocky bluffs at the bends, and is the most unfavorable portion of the route in regard to location and construction. The Baltimore and Ohio Railroad holds its way high up on the southern side of the ravine to gain the summit of the mountain at the head of Crabtree Creek. The valley is unsettled and wild, and covered with a rank growth of laurel, so that the line of the survey often followed the bed of the stream.

A gauging of the river just above its mouth gave a discharge of 18 cubic feet per second.

From Crabtree to Monroe Run, two and a half miles, the river turns sharply to the north, its bed rising at the rate of 53¾ feet per mile. The valley grows wider and has no bluff or rocky banks; thence to Blue Lick Run the direction is north-northeast for five and three-quarter miles, and thence to the summit of the mountain of Blue Lick, five and three-quarter miles, the direction is north with a convex bend to the east.

From the mouth of Crabtree the Savage River lies between the Savage Mountain on the east and the main Allegheny on the west, with a general direction north-northeast, reaching some sixteen or eighteen miles, crossing the National road some four miles west from Frostburgh, Md. From the mouth of Crabtree Creek to Chaney's Mill, on Blue Lick, near its head, the valley is wide and open, and has often several hundred yards width of bottom-lands; the river is without bluffs or rocky banks, and rising at the rate of 65 feet per mile. The general character of this section of the route is very favorable for the construction of a canal, there being room enough for a good location, and the hill-slopes having terraces favorable for supporting the levels of the canal to suitable sites for locks. A location can be made on the west side of the valley over this section without difficulty or obstacles to a point where the entrance to the summit-tunnel may be satisfactorily located.

From the summit of the mountain along Two-Mile Run to Piney Run, a distance of four miles, the direction is northeast, and thence along Piney Run to its junction with Castleman River, one mile north of Salisbury, Somerset County, Pa., the direction is north-northwest, and the distance is six and one-quarter miles, the ground falling at the rate of 79.4 feet per mile. Along Two-Mile Run, which crosses the National road at Shades, the same difficulty in surveying was met as on the first section of Savage River, and also as far down Piney as Ingle's Mill, within one mile of its mouth. From Ingle's Mill to the mouth of Piney the character of the valley is very favorable for location and construction on either side of the valley, being wide and open, with much bottom-land and meadow.

The survey having demonstrated the practicability of this route, the examination

might have closed when the valley of Castleman River was reached, but, for the purpose of making a more complete comparison of this route with the Will's Creek route, the survey was continued down the valley of Castleman River to Meyer's Mills, (Meyer's Dale City,) at the mouth of Flaugherty Creek, and thence to Blue Lick, these being the valleys into which the proposed tunnel led from Bowman's Run on Will's Creek. From Piney Run to Flaugherty Creek, a distance of six and a quarter miles, the river has several great bends, making a very crooked route, with a general direction nearly north, descending at the rate of 7½ feet per mile.

For the purpose of making close connections with the surveys of 1824 and 1828, and to aid in the identification of prominent points of those surveys, lines were surveyed three miles up Flaugherty Creek, and one and a half miles up Blue Lick. A bench-mark was pointed out and identified as one made by the surveying party of 1828, under the direction of Nathan S. Roberts, chief engineer of the board of engineers of the Chesapeake and Ohio Canal. This bench was marked 1828, and under this was 1,972, the latter being the elevation of the summit-level above tide at Georgetown. Our levels agreed with this elevation within one foot.

In addition to these examinations a survey was made of the portion of Savage River above Blue Lick, and to the same summit by way of Mud Lick Run, the most difficult part of our work. This route was so very crooked and so much longer than the Blue Lick route that it is not at all taken into consideration.

The whole distance thus surveyed was fifty-three miles, closing with the 1st of October. The distances here given are those made in the chaining of the survey in tracing the streams, and are greater than given in the approximate location for the canal for the purpose of estimating the cost. One-half the surveying party was dismissed on the 1st of October at Dale City. Returning to Salisbury the valley of Castleman River was examined instrumentally as far up as Plencher's Narrows, the site of one of the reservoirs proposed in connection with the summit of the Will's Creek route; and Meadow Run, a tributary of Castleman River coming in from the east just above Salisbury, was traced for a distance of two miles.

The surveying operations were closed here on the 14th of October, over sixty miles of line having been surveyed and leveled in two and one-half months.

The valley of Castleman River, above Salisbury, is a fine open, agricultural valley, thickly-settled, but not so rich and well-cultivated as the portion between Salisbury and Meyer's Dale City.

Taking with me two assistants, I made a reconnaissance of the headwaters of the North Branch, examining the river from Fairfax's stone, the southwest boundary-corner of the State of Maryland, to the crossing of the Northwestern Turnpike and Ryan's Glade Run, a distance of some fifteen miles, in which distance the river falls at the rate of 20 feet per mile. Thence to Bloomington, some twenty-eight miles, the fall is between 40 and 50 feet per mile. I had intended making an examination of the Black Water Fork of Cheat River, which is just over the mountain from the North Branch, but a snow-storm of eight inches depth on the 20th October prevented the carrying out this intention, and the remaining assistants were dismissed.

The valley of the North Branch is quite favorable for canal construction except in the rapidity of its rise.

During the time of our surveying operations the streams were at their lowest stages, and excellent opportunities were afforded for determining their minimum of supply. Several gauges of Savage River and Piney Run were made; also of Castleman River at Plencher's Narrows.

Mr. C. L. Fulton, assistant engineer, rendered efficient services as transit-man and in conduct of the surveying party, and Mr. Fred. W. Frost, civil engineer, was a competent and energetic leveler; and in fact all the gentlemen of the party rendered most efficient services, under untoward circumstances of bad weather, with becoming promptness and energy.

HISTORY OF FORMER SURVEYS.

The first authoritative move toward a system of national internal improvements was made in April, 1824, when Congress passed an act authorizing the President "to cause the necessary surveys, plans, and estimates to be made of the routes of such roads and canals as he may deem of national importance in a commercial or military point of view, or necessary for the transportation of the public mail, and to employ two or more skillful engineers and such officers of the Corps of Engineers as he may think proper to carry this act into effect."

In pursuance of this act, the then Secretary of War, John C. Calhoun, constituted a board of engineers, consisting of General Bernard, Corps of Engineers, Lieutenant-Colonel Totten, Corps of Engineers, and John L. Sullivan, civil engineer, who entered at once upon their duties, being assisted by many officers of the Army detailed for this purpose.

The board made very complete surveys and reports on routes for the Chesapeake and Ohio Canal, the Ohio and Erie Canal (since known as the Sandy and Beaver Canal) in

Ohio; Ohio and Schuylkill Canal, (now the well known Pennsylvania Canal;) Delaware and Raritan Canal; James River and Kanawha Canal, and many other routes for canals and roads.

The first examinations and surveys of a route for a canal to connect the Chesapeake Bay and the Ohio River, by the valley of the Potomac, on the eastern, and the Youghiogheny and Monongahela Valleys, on the western slopes of the Alleghany Mountains, were made in the summer of 1824, and were chiefly to determine the practicability of the undertaking, and were almost entirely restricted to the examination of the mountain or summit section between Cumberland, on the north branch of the Potomac, and the junction of Youghiogheny and Castleman Rivers, at Turkeyfoot.

The route thus surveyed in 1824 was by the north branch of the Potomac to the mouth of Savage River, and by Savage River, Crabtree Creek, and a branch of Crabtree Creek to Bear Creek and Deep Creek, and thence by the Youghiogheny to Turkeyfoot. That part of the route from Cumberland to the mouth of Savage River was surveyed by Maj. J. J. Abert, Topographical Engineers, and the remaining portion by Capt. William G. McNeill, Topographical Engineers.

The Baltimore and Ohio Railroad now occupies a portion of this route from Cumberland, but in ascending the mountains it diverges to the south, its summit being about eight miles south of the summit of the canal-route.

Several summit-crossings were surveyed, and careful gaugings were made of the streams most available for furnishing water for the summit-level, and an elaborate report was prepared by the board of engineers. They considered the route practicable with summit-tunnels from one and a third to five and a half miles in length, although the sum of the lockages between Georgetown and Pittsburgh was 3,837 feet, which exceeded anything that up to that time had been deemed feasible. The summit-level was found to be 2,408 feet above tide. It was to be supplied with water by means of large reservoirs to be constructed on the Youghiogheny River, at the point where it is now crossed by the route of the Baltimore and Ohio Railroad. (See Appendix A.)

During the next year a more careful and detailed survey was made "to determine the route to be recommended, as also to obtain the data necessary to frame a general plan of the work and a preparatory estimate of the expense." The report of this year (1826) was more complete than the former one, and discussed the character and general features of another route—that by the Valley of Will's Creek, leading northerly and easterly from Cumberland, and crossing the mountains to the Valley of Flaugherty Creek, which empties at Meyer's mill into Castleman River, a branch of the Youghiogheny River, which it joins at Turkeyfoot, near Confluence. The summit-level of this route was placed 440 feet lower than the summit-level of the Deep-Creek route, with a tunnel four miles long. The distance by the Will's-Creek line is eighteen miles shorter between Cumberland and Turkeyfoot than by the Deep-Creek line.

The supply of water for the summit-level was to be provided by two reservoirs on Castleman River, the lower one at Forney's mill, one mile below Salisbury and six miles from the west end of the tunnel-level, and the upper one at Plencher's farm, about five miles above Salisbury and about six miles above the one at Forney's mill, with which it was to be connected by a feeder. The water-supply was deemed to be more abundant than on the Deep-Creek route.

A survey was also made with a view to connect the reservoirs of the Deep-Creek route with those of the Will's-Creek route. This would necessitate a feeder of twenty-five miles in length to reach Plencher's farm, with one tunnel two miles long, and another five miles long and otherwise very expensive. This plan, however, was deemed feasible.

The report of 1826 was remarkable in that it gave a careful analysis of prices and probable costs, based on units of labor, of men and horses, and on the cost of producing lime, procuring stone, doing earth-work, obtaining transportation, &c., and these estimates were given for the separate divisions or sections of the proposed canal.

A carefully-prepared estimate was given in detail for characteristic sections of the work, varying from 300 yards to 15,000 yards in length.

The dimensions of the proposed canal were 48 feet width at top water-line, 93 feet at bottom, and five feet depth of water.

The section from Georgetown to Cumberland (one hundred and eighty-six miles) was estimated to cost	$8,177,081
From Cumberland to Turkeyfoot, (seventy and six-tenth miles)	10,028,123
From Turkeyfoot to Pittsburgh, (eighty-five and one-quarter miles)	4,170,224
Giving an estimated total cost of	22,375,428

This estimate of cost was so much greater than had been anticipated that all intentions of carrying out the enterprise were suspended.

The canal company was, however, granted a charter, and a convention was called to consider the conditions controlling the enterprise, and, among other actions taken, they appointed a committee to revise the estimates of the board of internal improve-

ments. This committee met at Washington in December, 1826, and on the most reliable information they could command, and, based upon the cost and contract-prices of similar works then in progress, they estimated the cost of the entire canal from Georgetown to Pittsburgh at $10,000,000. The estimates of the board were severely criticised as being very erroneous, and the then President of the United States, John Quincy Adams, was influenced to appoint a commission of civil engineers to examine the two sets of estimates and reconcile them. Messrs. James Geddes and Nathan S. Roberts, civil engineers of high repute, were appointed to that duty, and reported in 1828. They made the estimated cost of the canal from Georgetown to Cumberland, on the same scale of dimensions as proposed by General Bernard, $4,330,992, whereas the board's estimate for the same section was $8,177,081. This section was completed in October, 1850, at a cost of $11,071,176. Augmenting General Bernard's estimate by cost of lands for right of way, engineer expenses, damages, and salaries of officers, there was yet a difference of $2,087,816 over General Bernard's estimates, an increase of 25 per cent., but it is proper to state that the canal as built from Georgetown to Harper's Ferry, a distance of sixty miles, is 60 feet wide at water-line, 42 feet at bottom, and is 6 feet deep; from Harper's Ferry for a distance of forty-five miles it is 50 feet wide at water-line and 32 feet at the bottom; and thence to Cumberland, seventy-seven and one-half miles, it is 54 feet at top and 30 feet at bottom. The depth throughout its whole length is 6 feet. The locks are 100 feet long, 15 feet wide, with an average lift of 8 feet, and they will pass boats of 120 tons capacity. Some difference should also be allowed in favor of General Bernard's estimate for the increase in the value of money and of labor from 1824 to 1850.

I have been thus particular in reciting the history of these estimates because that portion of them relating to the cost of the canal from Cumberland to Pittsburgh must at present be taken to give an approximate cost of the proposed extension of the canal proper, reasonable additions being made to them for right of way, engineering expenses, and salaries, &c.; and it is, therefore, important to show their general correctness.

Messrs. Roberts & Cruger also made a location of the canal from Cumberland to Pittsburgh in 1828, following almost exactly the leading features of the plan proposed by the board of internal improvements, as to route, plans for reservoirs, &c., excepting only that they passed the summit by a tunnel from the same point on Bowman's Run to a point on Blue Lick Creek, instead of Flaugherty. Their estimate of the section from Cumberland to Pittsburgh was $7,732,661, while that of the board of engineers was $14,198,346.

WATER-SUPPLY.

The quantity of water needed to operate the canal is dependent on its character and dimensions, the size and lift of its locks, and the daily tonnage to be accommodated; and if the canal have a summit-level, we must consider its character and the length of canal on each side of the summit, which must be supplied therefrom.

The continual losses by surface evaporation, filtration, absorption, and waste at weirs and aqueducts, must also be supplied. All these sources of loss, except that by evaporation, can be reduced to reasonably small quantities by careful construction.

If we use the dimensions recommended by the board of internal improvements, we get a surface width of 48 feet, and locks 100 feet long, 15 feet wide, and 8 feet lift. These locks are adapted to the use of boats of 120 tons burden. [The average tonnage of the coal-boats now in use on the Chesapeake and Ohio Canal is about 112 tons.]

Boats alternately up and down through the locks can be passed at the rate of one boat in each eight minutes, or, say, seven per hour, or one hundred and sixty-eight per day of twenty-four hours, which is equal to a daily tonnage of 20,160 tons, or an annual tonnage of 6,148,800 tons for ten months of the year, the probable navigable season on this route. [The greatest number of boats passed through one lock in one day on the Erie Canal was 170 in 1862.]

The summit-level of this route is taken at an elevation of 2,100 feet above tide. Cumberland has an elevation of 603 feet, and the mouth of Savage River 960 feet above tide, while the Castleman River, at the mouth of Piney Run, has an elevation of 1,990 feet above tide.

Castleman River is a large stream amply sufficient to feed the canal westward from the summit. The ascent from the mouth of Savage River to the summit is at the rate of 65 feet per mile, and the tunnel is designed to pierce the mountains at an elevation about 100 feet higher than the mouth of Piney Run. There is not a sufficiency of water to feed the canal on the eastern slope of the mountain, above the mouth of Savage River, and a portion of the canal must be supplied from the summit-level.

We will now examine the condition of loss and supply of the section east of the summit, with a view to determine how much loss must needs be supplied from the summit-level.

The section from Cumberland to Savage River, thirty-one miles in length, can certainly be supplied from the daily discharge of the North Branch and Savage River.

Allowing the daily loss by evaporation, filtration, and absorption and waste at weirs to amount to three inches per day for each square foot of surface, we find a daily loss on this section of 1,964,140 cubic feet, (5,280 by 31 by 48 by $\frac{1}{4}$,) 2,273 cubic feet per second. No account has been taken of the leaking and spill at locks, as these quantities may be considered as the same at each lock, and this water merely passes from one level to another in the same manner as the prism of lift, without loss to the canal.

Several gaugings of Savage River, near its mouth, gave an average discharge of 18 cubic feet per second, and north branch was estimated to deliver at least three times as much more, or 54 cubic feet per second, making an available supply of 72 cubic feet per second, or more than three times the estimated quantity required.

These estimated losses of water are taken for a well-made, puddled canal of favorable conditions. A new canal during the first year or two would probably lose twice this quantity per day; and if the canal were occupied by active transportation the agitation caused thereby would slightly increase the loss by evaporation and waste; however, these causes cannot have a maximum effect except when the canal is well filled with water. No account is taken of the lockage at present, because the prism of lift-water passes from level to level like the spill and leakage at the locks. If provisions be made for feeding the canal at one or two other points before reaching Cumberland—say at half way—then the loss to be supplied at the mouth of Savage River would be but one-half that stated above, or 982,100 cubic feet, less than 12 cubic feet per second, and only two-thirds of the quantity of water discharged by Savage River alone.

The summit-level is at a distance of sixteen miles from the mouth of Savage River, the ascent being 1,140 feet, and therefore requiring 143 locks of 8-foot lift, or 114 locks of 10-foot lift.

The daily loss from evaporation on this section would, in accordance with the above data, be less than 12 cubic feet per second. There is no other available constant supply of water east of the summit for this section than the Savage River, which in August last gauged but 6 cubic feet per second at the mouth of Blue Lick. To supply the remaining 6 cubic feet per second—518,400 cubic feet per day—during the months of July, August, and September, will require a reservoir capacity of about 52,600,000 cubic feet, including a loss by evaporation of one-quarter of an inch per day on reservoirs of 15 feet depth, without regard to either steady or periodical influx during that time. The available places for reservoirs are the valleys of Crabtree Creek, Monroe Run, Poplar-Lick Run, and the Savage River, above the mouth of Blue Lick Run. Allotting one-fifth of this quantity (say 10,500,000 cubic feet) to each of the three first-named places, we find that these reservoirs must be 1,800 feet long, 500 feet wide, and must average 12 feet in depth. Allotting to the Savage River the remaining two-fifths of the quantity to be stored, or 21,000,000 cubic feet, we must provide a reservoir 2,500 feet long by 560 feet wide, averaging 15 feet in depth. This can readily be done. A much larger reservoir can be provided on the Upper Savage than is herein required, the valley being very favorable in its topography, as was developed by our survey. That these reservoirs would be filled in the spring months is beyond doubt, as an influx of 4 cubic feet per second would fill either of the smaller ones in thirty days, and the larger one in double that time; and all these streams deliver from 10 to 20 cubic feet per second in March or April, when the snows are melting; while only two-fifths of a cubic foot per second is needed to replace the evaporation on one of the smaller reservoirs.

We come now to consider the summit-level with a tunnel of five miles in length, and a basin at each end one-half a mile long and 32 feet wide, the tunnel itself having 32 feet width of water. The evaporation in the tunnel may be taken as nothing, as in fact there is always an infiltration at tunnels that may be utilized in this case, and assuming that the tunnel may be brick-lined, we need only consider the loss by evaporation, &c., on the two basins, or open portions, and that by leakage and spill at the locks at each end of this level. The latter may be taken at 1,000 cubic feet per hour at each lock. Assuming as before the daily loss by evaporation, absorption, and filtration at 3 inches of depth per day, we obtain for one mile of canal a loss of 42,240 cubic feet per day, which, increased by 48,000 cubic feet for loss at locks, gives a total waste on the summit-level of 90,240 cubic feet per day. But the loss from evaporation, &c., between the tunnel and the mouth of Piney Run on the west, and the mouth of Blue Lick on the east, a total distance of nine and a half miles, must also be supplied from the summit-level, and this causes an additional daily loss of 601,920 cubic feet, making a total daily loss, which must be made good, of 692,160 cubic feet per day.

To determine the quantity of water drawn from the summit-level by lockage, we must assume that a certain number of boats will pass the summit daily. If boats follow each other in the same direction over a summit-level, each will take from this level two lockfuls of water; but if they alternate uniformly, boat with boat, then each boat draws off but one lockful of water. For the purposes of this estimate, we will assume that two-thirds of the boats passing daily are going in the same direction, and the other third in the contrary direction, and thus each boat may be charged as drawing off one and a half lockfuls each, equal to 18,000 cubic feet.

We will for the present consider the daily tonnage to equal 100 boats per day, re-

quiring 1,800,000 cubic feet of water for lockage daily, to which add the daily loss from evaporation, absorption, filtration, and leakage heretofore found, (672,160 cubic feet,) and we have a total daily loss on the summit-level of 2,492,160 cubic feet or 28.8 cubic feet per second.

The only available source of supply for feeding this summit-level is Castleman River, into whose valley the tunnel opens. The elevation of the summit-level has been taken with special reference to obtaining the necessary feed-water from the Plencher reservoir on Castleman River, which was originally designed for the Will's Creek route. The average supply or discharge of the river is greater than the quantity required, as the following gauging will show:

	Cubic feet.
June 21, 1825, at Plencher's, per second	18
July 10, 1825, below Flaugherty, per second	38
July 12, 1825, mouth Flaugherty, per second	46
March 21, 1825, at Plencher's, per second	98
March 21, 1825, below mouth of Piney, per second	536

At the time of our survey a gauging of the river at Plencher's Narrows gave 25 cubic feet per second.

Taking the same capacity of reservoirs as that proposed by the board of internal improvements, namely, 126,333,780 cubic feet, this amount would be furnished in fifteen days, according to the gauging of March 21. If we assume that only half of this daily supply could be expected, we yet find that the reservoir could be filled in any one of the spring months.

This reservoir was stated to have a surface-area of 9,365,400 square feet, from which the daily evaporation, at a rate of one-fourth of an inch per day, would be 195,120 cubic feet, giving the total daily consumption and loss as follows:

	Cubic feet.
Lockage of 100 boats	1,800,000
Evaporation, &c., summit-level	90,240
Evaporation, &c., on 9½ miles of canal	601,920
Total daily consumption	2,582,160

This is at the average rate of 31 cubic feet per second. It may be safely assumed that this daily consumption would be met by the average daily discharge of the river, except during the months of July, August, and September, but during these months the natural flow, at a rate of 18 cubic feet per second, the lowest gauging given, would put into the reservoir 1,555,200 cubic feet per day, leaving only 1,133,440 cubic feet to be supplied from the previous accumulations. At this rate the reservoir would not be emptied in less than one hundred and eleven days, or in four months less nine days, even if there should be no rain-fall during the months named.

In addition to this supply, a reservoir is practicable on Meadow Run, and another, of a probable capacity of 25,000,000 cubic feet, on Piney Run, which has a supply of 3 feet per second at Findlay's Mill during the average summer discharge. Assuming for the Meadow Creek reservoir an equal capacity and a depth of 10 feet in each, the loss by evaporation would be for both 104,200 cubic feet per day, and the influx (allowing only two feet per second for Meadow Run) 432,000 cubic feet per day.

The Meadow Run feeder would probably be about one mile in length, and the Piney Run feeder about three and one-half miles. Assuming each feeder to have a width of 20 feet, we thus have a total feeder-surface for these two reservoirs of four and one-half miles in length and 20 feet in width. According to our previous allowance of 3 inches vertical on each square foot for losses by all causes, we have a total daily loss on these two feeders of 118,800 cubic feet.

We would thus have a storage capacity of 176,333,780 cubic feet, and a daily flow into the reservoirs of 1,987,200 cubic feet. On the other hand, we have a daily consumption on the canal of 2,582,160 cubic feet, and a daily loss on reservoirs and feeders of 418,120 cubic feet. The daily drain on the supply stored would therefore be 1,013,080 cubic feet, which would not exhaust them in less than 174 days, or about six months. If the total influx were but 12½ cubic feet per second, the reservoir would last 92 days, even should the canal be worked to its maximum capacity throughout the driest season of the year, conditions that seldom occur and act conjointly for the whole season of the three dry months. Any less amount of business than has been assumed, (equal to 3,600,000 tons during a navigation season of ten months, and the tonnage of the Erie Canal is given as 3,562,500 tons for 1872,) or any rain-fall during the months named, renders more certain the adequacy of the supply; and only the careless construction of the canal and its appurtenances, or the increase of business over that supposed, or a more protracted drought than has ever been known in this region, can render the supply inadequate.

The data used for evaporation, absorption, and filtration and waste, are the averages of the best authorities, and they are 50 per cent. greater than are taken for the canals of Great Britain.

If we consider the summit supply as dependent on the average annual rain-fall and the catchment-basins, we find that the catchment-basin of the Plencher reservoir is very nearly twelve miles long and five miles wide, and has an area of sixty square miles. The average annual rain-fall at Pittsburgh, Pa., was 34.96 inches for eighteen years; at Marietta, Ohio, 41.58 inches for twenty-eight years; at Portsmouth, Ohio, 38.20 inches for fifteen years; at Carlisle, Pa., 34.00 inches for six years; and at Gettysburgh, Pa., 38.80 inches for seven years. If we take an average of these as representing the annual rain-fall for the region under consideration, we get 38 inches per annum. Applying this to the catchment-area given, and assuming that but one-third of the quantity is caught by the reservoir, we have an annual quantity of 1,698,965,300 cubic feet, enough to fill the reservoir thirteen times; and the Piney Run reservoir, with a catchment-area of twelve square miles, would also be filled thirteen times; the total annual supply by rain-fall being 2,038,758,360 cubic feet, which gives an adequate supply for the uses of the canal during a period of twenty-five months, with allowances for evaporation of reservoirs and loss in feeding.

Again, if we take an average of the gaugings in March and June as representing the available rain-fall that will be caught by the Plencher reservoir, we get 1,829,088,000 cubic feet as the annual supply; whereas the consumption for the uses of the canal would be for ten months 780,000,000 cubic feet, or only about 43 per cent. of the estimated supply. This estimate of consumption is twice as great as that assumed by the board of internal improvements.

The changed conditions with reference to the Forney-mill reservoir, considered essential to the supply of water for the Will's Creek route, renders it of doubtful present practicability. Its site is at the mouth of Piney Run, with a dam one-quarter of a mile below, and the height proposed would raise the water to a contour-line 30 feet above the present surface of the mill-dam at that place; would reach nearly one-fourth the distance to Plencher's Narrows, and nearly a half mile up Piney Run; would flood the road from Salisbury toward Meyer's Dale City for a distance of half a mile, and would submerge the bridge at Livengood's mill, and the one at the mouth of Piney Run; it would also cover the road and bridge toward Grantsville, about one mile of a graded railroad, to a depth of from 10 to 20 feet, two mills now in operation, a large area of valuable meadow farming-land, and a part of the surveyed site of the town of Salisbury.

A low dam now in use on this site, if made tight, would save the water-supply for feeding the canal below the mouth of the Piney Run.

I have personally examined Castleman River to some distance above Plencher's Narrows, and find that a reservoir of considerable capacity may be constructed at the crossing of the national road, about two miles above Plencher's. That would be a very useful auxiliary for storing water for the summit-level, saving a portion of the drainage that in spring floods would waste over the Plencher dam.

There is yet another source of supply for the summit-level on the Upper Savage at the crossing of the Lonaconing road, where the elevation of the stream is 2,180 feet at the distance of five and a half miles from the mouth of Blue Lick. The topography is very favorable for a large reservoir—say of a capacity of 80,000,000 cubic feet. Thus the summit supply would be increased by nearly 50 per cent. and furthermore provide an ample supply to replace the loss by evaporation on the fourteen-mile section from the summit-level to the mouth of Savage River. If reasonable expense were incurred in puddling or lining the feeders, with a view to reduce the loss in transmission of supply to a minimum, the supply of water would be sufficient for the most active business of the canal.

The tunnel enters the valley of Castleman immediately at the Plencher reservoir, and there would not be any loss on feeding therefrom, but the feeders from Meadow Run and Piney Run, if brought to the summit-level, should probably be lined, but if fed into the canal at shortest distances they would not need to be lined.

ESTIMATE OF COST.

In making this estimate of cost I have adhered to the dimensions recommended by the board of internal improvements in their report of 1826, viz: 48 feet width at water-line; 33 feet width at bottom, and 5 feet depth of water; locks 100 feet long, 15 feet wide, and of 8 feet lift; because reference must be had to the quantities of work to be done as estimated by them between Cumberland and the mouth of Savage River, and from Meyer's Mill to Pittsburgh. These dimensions are very nearly the same as those of the completed canal between Harper's Ferry and Cumberland, a distance of one hundred and twenty-five miles, equal to two-thirds of the length of the finished canal.

Section from Cumberland to mouth of Savage River, length thirty-one miles, lockage 334 feet.

1,336,600 cubic yards excavation, earth, at 30 cents per yard	$400,980
300,000 cubic yards excavation, rock, at $1.25 per yard	375,000
1,300,000 cubic yards embankment, at 20 cents	260,000
200,000 cubic yards retaining-wall, at $1.50	300,000
270,000 cubic yards puddling, at 10 cents extra	27,000
40 culverts, (arches,) at $2,000 each	80,000
42 locks, 8 feet lift, at $15,000 each	630,000
2 aqueducts, 120 feet and 210 feet, (wooden)	10,500
1,000 cubic yards aqueduct masonry, at $10	10,000
4 waste-weirs, $3,000 each	12,000
30 farm-bridges, at $450	13,500
5 miles grubbing and clearing	1,250
3 dams, at $3,000 each	9,000
400 acres land-damages, at $50	20,000
Special damages, water-powers	15,000
Engineering and superintendence	75,000
Sum of items	2,239,230
Contingencies, 10 per cent	223,923
Cost of thirty-one miles, averaging $79,456.55	2,463,153

These quantities are made from a comparison of those of the board of internal improvements, and those of Messrs. Roberts and Auger. Adding the items of farm-bridges, waste-weirs, land and special damages, and engineering superintendence, growing out of the changed conditions of then and now, the average cost per mile of this section, by the board of internal improvements, was $59,476.

From the mouth of Savage River to Crabtree Creek, distance five and a half miles, lockage 388 *feet.*

150,000 cubic yards excavation, earth, at 30 cents	$45,000
50,000 cubic yards excavation, rock, at $1.20	60,000
80,000 cubic yards embankment, at 20 cents	16,000
10,560 cubic yards retaining-wall, at $1.50	15,840
40,000 cubic yards puddling, at 10 cents extra	4,000
3 culverts, at $1,500 each	4,500
48 locks, at $13,500 each	648,000
1 aqueduct	3,000
900 cubic yards masonry, at $8	7,200
5 miles grubbing and clearing, at $300	1,500
Dam and feeder, Crabtree Creek	15,000
2 dams	3,000
Engineering and superintendence	12,500
Sum of items	835,540
Contingencies, 10 per cent	83,554
Cost of $5\frac{1}{2}$ miles, averaging $167,108	919,094

The rock-excavation on this section is a sandstone stratum, and more cheaply worked, and being of a quality suitable for the required masonry, and close at hand, the masonry can be more cheaply done. The average cost is great; but there are nine locks per mile, making more than 70 per cent. of the cost.

From Crabtree Creek to summit-level, distance eleven miles, lockage 732 feet.

800,000 cubic yards excavation, earth, at 30 cents	$240,000
400,000 cubic yards embankment, at 20 cents	80,000
140,000 cubic yards puddling, at 10 cents extra	14,000
10 culverts, at $1,500 each	15,000
92 locks, at $13,500 each	1,242,000
10 miles grubbing and clearing	2,500
5 crossing-bridges, at $450	2,250
5,000 cubic yards protection, at $1.25	6,250
2 reservoirs and feeders	20,000

1 reservoir and feeder	$15,000
Engineering and superintendence	25,000
Sum of items	1,662,000
Contingencies, 10 per cent	166,200
Cost of 11 miles, averaging $166,200	1,828,200

On this section ninety-two locks make two-thirds of its cost. The reservoirs for Monroe Run, Poplar Lick, and the Upper Savage are included.

Summit-level, six and a half miles long.

This level comprises a tunnel five miles long and approach-basins each three-quarters of a mile long. The dimensions of the tunnel are given by a segmental circular section of 32 feet diameter, with a height of 26 feet from bottom of tunnel to crown of arch, providing a waste-way 25 feet on bottom, 6 feet deep, and 32 feet on top, and a head-way of 20 feet; the lining to be of the best hard brick, with a thickness of 18 inches all around the section. Horizontal fenders are to be laid at water-line, to act as fenders for passing boats and to protect the brick-masonry from injury. The approaches are to give a top water-line of 32 feet and a bottom width of 25 feet, (in rock-cutting.)

No provision is made for a tow-path, because the additional cost of doing so, say $500,000, would, at 7 per cent. interest, maintain and operate five tug-boats, enough for the business of 100 boats per day.

870,000 cubic yards excavation, tunnel, at $5	$4,350,000
2,500 cubic yards excavation, shafts, at $5	12,500
81,000,000 brick, lining of tunnel, at $25 per thousand	2,025,000
600,000 brick, lining of shafts, at $25 per thousand	15,000
180,000 feet (board-measure) fenders, at $30 per thousand	5,640
200,000 cubic yards rock-excavation, approaches, at $1.25	250,000
20,000 cubic yards concrete-filling about arch, at $10	200,000
10,000 cubic yards puddling, at 30 cents	3,000
44,000 cubic yards filling on top of arch, at $1	44,000
Engineering and superintendence, 5 years	50,000
Sum of items	6,955,140
Contingencies, 20 per cent	1,391,028
Cost of summit-level	8,346,168

From summit-level to the mouth of Piney, five and a quarter miles.

300,000 cubic yards excavation, earth, at 30 cents	$90,000
50,000 cubic yards excavation, rock, at $1.25	62,500
200,000 cubic yards embankment, at 20 cents	40,000
60,000 cubic yards puddling, at 10 cents extra	6,000
8 culverts, at $1,500 each	12,000
1 aqueduct over Piney Run	5,000
16 locks, at $15,000 each	240,000
450 cubic yards abutment-masonry, at $8	3,600
Grubbing and clearing	600
6 bridge-crossings, at $450	2,700
Land-damages	10,000
Engineering and superintendence	10,000
Sum of items	482,400
Contingencies, 10 per cent	48,240
Cost of 6½ miles, (averaging $81,636.90)	530,640

From mouth of Piney to Meyer's Mill, six and a quarter miles.

200,000 cubic yards excavation, (earth,) at 30 cents	$60,000
30,000 cubic yards excavation, (rock,) at $1.50	45,000
500,000 cubic yards embankment, at 20 cents	100,000
50,000 cubic yards puddling, at 10 cents extra	5,000
3,000 cubic yards protection, at $1.25	3,750
6 locks, at $15,000 each	90,000
8 culverts, at $1,500	12,000
10 crossing-bridges, at $450 each	4,500
Grubbing and clearing	300
1 aqueduct for Elk Lick	4,500

Repairing dam at mouth of Piney, &c	$5,000
1 waste-weir	1,800
Land-damage, 100 acres, at $100	10,000
450 cubic yards abutment-masonry, at $8	3,600
Engineering and superintendence	15,000
Sum of items	360,000
Contingencies, 10 per cent	36,000
Cost of 5½ miles, averaging $72,000	396,000

PLENCHER RESERVOIR AND FEEDER.

Dam with regulating and outlet-pipes	$35,000
Meadow and Piney Run reservoirs and feeders	60,000
Sum of items, summit feeders	95,000

From Meyers' Mills to the vicinity of Connellsville the board of internal improvements considered the work in three characteristic sections.

The first section west from Meyers' Mills of sixteen and one-eighth miles, with 216 feet of lockage and 27 locks, was estimated to cost $1,240,216, averaging $76,912.62 per mile. Deducting therefrom one and one-eighth miles from the summit-level to the valley, where our line would join theirs, we get thus:

1st section, fifteen miles, 192 feet lockage	$1,163,304
2d section, nineteen and six-tenths miles, 420 feet lockage	1,457,317
3d section, twenty-seven and one-half miles, 432 feet lockage	1,515,437
Meyers' Mills to Connellsville, sixty-two miles	4,138,058
Increasing this estimate at the rate of 25 per cent. as found to apply to the section between Cumberland and Savage River	1,034,515
Sum representing estimate	5,172,573
Contingencies, 10 per cent	517,257
Cost of sixty-two miles, averaging $91,771.45	5,689,830

I have carried the estimate as far as Connellsville for the reason that I am informed that a company has been formed and incorporated by the State of Pennsylvania for the purpose of establishing slack-water navigation as far east on this line as Connellsville, or Ohio Pile Falls; and the section from Cumberland to Connellsville represents fairly the extent of canal needed to be provided to complete the water-line to Pittsburgh.

The recapitulation is as follows:

Cumberland to Savage River, 31 miles	$2,463,153
Mouth of Savage to Crabtree, 5½ miles	919,094
Crabtree to Summit, 11 miles	1,828,200
Summit-level and tunnel, 6½ miles	8,346,168
Summit to mouth of Piney, 5¼ miles	530,640
Piney to Meyers' Mills, 6¼ miles	396,000
Reservoirs and feeders, (Summit)	95,000
Meyers' Mills to Connellsville, 62 miles	5,689,830
Cumberland to Connellsville, 127½ miles, averaging $158,887 per mile	20,268,085

Comparing this estimate of cost with that of the board of internal improvements for the same section of work between the same places, we have from their estimate:

Cumberland to Summit-level	$3,856,624
Summit-level	3,471,967
Summit to mouth of Castleman	2,699,532
Castleman to Connellsville	1,515,437
Total, including reservoirs and feeders	11,543,560
If the tunnel and approaches had been taken of the same dimensions as for the Savage River route, they would have added	650,000
Making a total of	12,193,560
Adding 25 per cent., as before	3,048,390
We have	15,241,950
Contingencies, 10 per cent	1,524,195
Cost of ninety-eight miles, averaging $171,083	16,766,145

Showing an average $12,739 more per mile than by ur estimate.

The difference between the two estimates of $3,501,890, if reduced by the cost of the increased number of locks and greater length of tunnel on the Savage River route, will be but $2,003,000, reducing the average cost per mile to $147,207, indicating the more favorable character of the route in regard to cost of construction, as was stated in the description of the character of the route.

If, in further comparison of the Will's Creek and Savage River routes with reference to their costs now, we take into consideration that the Will's Creek route between Cumberland and Meyers' Mills is occupied by a railroad in operation holding almost the very ground on which the canal was located, in a valley of which a great portion is not wide enough for two such works, and wherein the canal would necessarily have to be located across the railroad several times under the most unfavorable conditions, and with a second railroad between Cumberland and Little Will's Creek, a distance of fifteen miles, the present recast of the former estimate would fall far short of the extraordinary expenses that are contingent upon the above conditions. It may be affirmed of the Savage River route that "*it would not cost more than the Will's Creek route.*"

The tunnel on the Deep Creek route was planned for a length of one and one-third miles, but the western deep cut approach would be *five and one-quarter miles long.*

The quantities given in this estimate of cost are as correct as may be, without a more detailed survey and a definite location. The line of the proposed tunnel could not be surveyed to determine its precise length, nor the character of the approaches thereto, nor the location and depth of shafts, all which were determined from the preliminary survey. It is but a reasonable presumption that a careful study of the ground would indicate a somewhat shorter tunnel by correction of chaining and plat, and indicate favorable places for the approaches thereto, that would reduce the estimate of cost.

The strata that would be pierced by the tunnel are inclined at angles of 15° to 20°, are carboniferous, and contain a portion of the "*lower coal-measures,*" as described in Professor Lesley's report. The unfavorable condition of the pierced strata would necessitate the lining of the water-section of the tunnel to preserve the summit feed-water.

The tunnel is presumed to be operated by steam-tugs, for the reason that a sufficient number of them can be maintained and operated to accommodate the presumed business of the canal at a cost far less than the interest on the cost of increasing the size of the tunnel, so as to provide it with towing-paths; it is, however, wide enough to be operated in both directions at the same time, as it was thought that the delays in operating a long tunnel only wide enough for one boat would be very burdensome to business. Assuming a speed of three miles per hour through the tunnel, boats arriving shortly after a convoy had started through would be detained nearly four hours, and while waiting, if the season were a busy one, boats would rapidly accumulate until there would be more than could be taken through in one convoy, and a blockade that could not be remedied would be formed; in the same manner a narrow tunnel with a tow-path would cause a still more serious obstruction to business, as a convoy would consume at least three hours in passing through the tunnel, and thus there would be greater delays and unavoidable blockades. If steam should be brought to supersede horse-power on the canal, the tunnel would be favorably conditioned for accommodating the maximum traffic that could pass through the other portions of the canal.

The tunnel could be operated with an endless chain, or wire-rope, worked by stationary machinery, or by pneumatic tubes fixed on the sides of the tunnel in connection with fixed engines, so arranged as to tow single boats at from four to six miles per hour.

The present state of the enterprise does not warrant an investigation of these suggestions.

An examination has been begun to determine the conditions governing the introduction of inclined planes as substitutes for locks, their economic value as to cost, and economy of time, and water-supply, and their applicability for carrying canal transit-routes over high mountain-ranges.

COMMERCIAL IMPORTANCE.

Of the importance to be attached to the extension of the Chesapeake and Ohio Canal as one of the water-lines of transportation between the Atlantic seaboard and the great cereal-producing region of the great Mississippi Valley, nothing can be added to the volumes that have been devoted to that subject since Washington first interested himself in the scheme of improving the navigation of the Potomac River, with the ultimate purpose of bringing the products of the then West to the seaboard by this route.

The unparalleled development of the great West into a dense population of agriculturalists and collaborators renders the necessity of extension of this route urgent, and the condition of monopolies controlling the transportation of the products of the West, establishing the condition of middlemen between the consumers and producers at a ruinous cost, bring about the clamorous demands for its early completion.

The products of the region referred to may be stated as 40,000,000 tons, of which

25,000,000 tons, at least, are destined for market. The capacities for carrying this eastward are as follows, based upon the work done by the routes named:

The Erie Canal carries in one year, tons	2,640,000
The Erie Railway, tons	895,000
The Pennsylvania Railroad, tons	880,000
The Baltimore and Ohio Railroad, tons	600,000
The New York Central Railroad	1,200,000
The other railway lines, say, tons	500,000
Total	6,715,000

Showing that only about one-fourth of the products seeking a market come direct to the east, and that more than one-third seeks the cheapness of the water-line.

The necessity and utility of additional cheap water-lines of transportation is apparent. Further illustration of the utility of this work as a through line of transportation is uncalled for, in view of the forthcoming report of the United States Senate Committee on lines of transportation; but the local interests dependent on the *extension* of this route are worthy of special consideration.

The first consideration is the further development of the valley of the North Branch of the Potomac River above Cumberland and its several tributaries, in the progress of which the low rates of transportation by canal as compared with railroads are of the first importance.

The second important consideration is the establishment of canal transportation to the Cumberland coal-basin at Piedmont, twenty-eight miles beyond and west of Cumberland, by which convenience the cost of coal to the sea-coast market should be reduced by $1.65 per ton on present rates by railroads, and a dollar per ton on present combined rates on railroad and canal.

As a third consideration, there are extensive beds of the *lower coal-series*, described in the appended report of Professor Lesley, (Appendix B.) On the North Branch, from the mouth of Savage River to its head-waters, a length of some thirty miles, are extensive forests of the finest of timber, both on the North Branch and the Savage, already in demand, and now taken to market under great disadvantages and at heavy cost.

But the most important feature, and the one promising the greatest benefit, one that will soon be demanded as a great necessity for the extension, is the fact that the Savage River route traverses the very valuable and extensive *Salisbury coal-basin*, which by calculation contains 90,000,000 tons of coal that can be brought to market out of a deposit estimated at 154,000,000 tons, lying above the bed of the Castleman River, at the place where this route enters the valley. The quantity available from the *lower coal-series*, lying below the bed of the river, is estimated at 90,000,000 tons out of a deposit of 120,000,000 tons. The upper beds can be worked by galleries and adits nearly horizontal, are readily drained, and are identical with the great Pittsburgh, Sewickly, and Cumberland beds, and of same general quality.

Late estimates the quantity of coal remaining of the great vein of the Cumberland basin gives, for 1869, 112,000,000 tons. This basin is being exhausted at the rate of 2,000,000 tons per annum, increasing at the rate of 5 per cent. each year, and at this rate will be exhausted in about twenty years; and the next available coal-field is the Salisbury basin, only some twenty miles more distant from the eastern markets, and yet within economic distance.

The Cumberland coal is now taxed by railroad freights $3.16 per ton per two hundred and twelve miles, quite nearly one and a half cents per ton per mile. This coal could be brought to the seaboard by canal for $1.06 per ton exclusive of tolls, which would be in full business, say 30 cents per ton, a total of $1.36 per ton, a saving to the consumer of $1.80 on present prices, or nearly 36 per cent.

The Salisbury beds are opened in several places, and a railroad is graded to connect with the Baltimore and Pittsburgh line. The Keystone Coal Company are mining and putting coal on the Baltimore and Pittsburgh Railroad by a narrow-gauge line at the rate of 150 tons per day; but the railroad monopoly obstructs the getting of the products of this coal-basin to market, and retards and delays the operations of mining; and consequently the Cumberland Coal Companies avoid competition; all which reacts on the prices at the eastern coal-markets, to the great disadvantage of all classes of consumers, domestic and productive.

For a faithful and full report on the Salisbury coal-basin with regard to quantity, quality, and geological identity, I am enabled to refer to the accompanying report of Prof. J. P. Lesley, for the use of which I am indebted to the courtesy of Mr. John Anspach, president of the Salisbury and Baltimore Railroad and Coal Company; I am also indebted to Mr. Frank T. Wilson, engineer for the company, for valuable information and professional courtesies.

That the lower coal series can be extensively worked on the north branch above the mouth of Savage River is without question, as many places are opened to veins of 6 and 8 feet thickness, and even of greater thickness, near the head of that stream.

The importance of this extension is also apparent in regard to reaching the several coal-field of the Youghiogheny, referred to in Professor Lesley's report.

APPENDIX A.

Report of the board of internal improvement on the Chesapeake and Ohio Canal, February 2, 1825.

This canal may be divided in three sections—eastern, middle, and western. The eastern section extends from the tide-water in the Potomac to the mouth of Savage River, in the northern branch of the Potomac. The middle section extends from the mouth of Savage River in the Potomac to that of Bear Creek in the Youghiogheny. The western section from the mouth of Bear Creek to the Ohio at Pittsburgh.

EASTERN SECTION.

[As this section has been built, all matters relating to it are omitted.]

MIDDLE SECTION.

This section, from the mouth of Savage River in the north branch of the Potomac extends to the mouth of Bear Creek, in the Youghiogheny, on the west side of the Alleganies. It includes the summit-level of the canal, and from the complicated topography of the ground, the height which must be overcome in a short space, and the difficulty of securing a sufficient supply of water in dry seasons at such an elevation, presents the greatest difficulties which occur in the whole project.

The Little Back Bone Ridge divides the waters, which, in that part of the Alleganies, runs east and west; it runs parallel to the Great Back Bone, through which Savage River forces its way, and the canal must absolutely pass through this gap. Between those two ridges run Crabtree Creek, from southwest to northeast, and Savage River from northwest to southeast, the former falling into Savage River four and a half miles above its mouth in the Potomac. From the west side of the Little Back Bone falls Deep Creek and the Little Youghiogheny; the latter runs from east to west, and, after forcing its way successively through Hoop-pole Ridge and Roman Nose Ridge, joins the Great Youghiogheny. Deep Creek runs at first to the north, crossing Hoop-pole Ridge and Negro Mountain; then, intercepted by Marsh Mountain, it turns west and falls into the Youghiogheny. The gap through which it forces its way across the Hoop-pole Ridge is only sixty-six yards wide, and is called the Narrows.

The heads of the Little and Great Youghiogheny, to some miles above the point where they join in a single stream, run through marshy meadows known by the name of Glades. The valleys of Deep Creek and its tributaries offer the same features as low down as Marsh Mountain, from whence their course continues in a deep and narrow ravine, with steep and rugged banks. The bottom of these glades, which has been sounded in several places, present the following layers: first, rich loam; second, sand, colored by oxydated iron; third, vegetable detritics; fourth, alluvial clay; fifth, a horizontal bank of sandstone, 4 or 5 feet below the surface, on which the other layers all lie.

The Great Youghiogheny, after receiving the Little Youghiogheny and Deep Creek, receives Bear Creek. The east branch of this last stream rises on the west side of Negro Mountain, and runs from south to north till it forces its way through Keyser's Ridge; it then runs suddenly west, and, after forcing through Winding Ridge, falls into the Youghiogheny. Its west branch springs from the west side of Keyser's Ridge, and joins the other at the gap, where it forces its way through Winding Ridge.

Savage River runs on a bed of sandstone; its course is rapid, and broad flats extend along both its banks. Crabtree Creek is the chief tributary stream which joins it; it runs between the Great and Little Backbone, and is formed by the junction of Crabby's Arm and Wilson's Fork, which take their sources in that part of the Little Backbone which divides their ravines from the valley of the Little Youghiogheny. Crabby's Arm runs in a narrow vale, but which is, however, wide enough to receive a canal; its bottom is a black, alluvial soil, and its banks present a gentle slope. Wilson's Fork is more rapid, but runs in a wide and well-wooded valley. These two streams join at Swan's Mill, from whence they impetuously descend on a bed from ten to twenty yards wide. They are interrupted in two or three places by perpendicular falls, 7 or 8 feet high, and frequently by smaller rapids, which fall from 4 to 5 feet. From the Great Backbone, Crabtree Creek receives several tributaries; they are torrents which fall into it with great impetuosity. On both sides of its valleys run flats eight or ten yards wide, which are intersected by rugged bluffs, from 100 to 200 feet high, which divide them into isolated portions, the bluffs on one side of the stream lying, in general, opposite to the flats on the other, and the two banks presenting an alternate succession of the same features.

Such are the main streams which, in this section, descend from the two sides of the Alleganies.

To conduct the canal across this summit ground we must, 1st, select the best passage for it through the Little Backbone, by leading it either from the valley of Savage River to that of Deep Creek, and from that of Crabtree Creek to the same, or from the valley of Crabtree Creek, to that of the Little Youghiogheny; 2d, ascertain which of these passages presents the shortest route from the mouth of Savage River to that of Bear Creek; 3d, ascertain, as the most essential element of the whole project, whether a supply of water sufficient for all the purposes of the canal can be procured at this elevation.

We shall point out the several passages which lead through the Little Backbone, beginning by those which lead from the valley of Savage River to that of Deep Creek. But, in the first place, it is necessary to state that a base-mark has been fixed on the bridge of Deep Creek, 3 feet above its bottom; to this have been referred all the levels taken on this section of the canal.

Monroe Run, a tributary of Savage River, and Meadow Mountain Run, a tributary of Deep Creek, offer the only ravines through which Deep Creek and Savage River can be connected. For this purpose it will be necessary to run a tunnel through the Little Backbone. Supposing its bed on a level with the base-mark, and a deep cut of 35 feet at each extremity of it, this tunnel would extend 5 miles 833⅓ yards in length. The greatest elevation of the ridge above the bed of the tunnel would be 213 feet. From its eastern extremity to the mouth of Monroe Run, in Savage River, the descent is 983 feet, on length of 5 miles 816⅔ yards. From the mouth of Monroe Run to that of Crabtree Creek, in Savage River, the descent is 109 feet on a length of 2 miles 216⅔ yards. From the mouth of Crabtree Creek to that of Savage River itself, in the Potomac, the descent is 340 feet,on a length of five and one-half miles. The level of the mouth of Savage River lies, of course, 1,432 feet below the base-mark, and at a distance of 21 miles 327 yards from it, ascending the ravines of Savage River and Monroe Run, and descending those of Meadow Mountain Run and Deep Creek.

Meadow Mountain Run flows through glades, but Monroe Run falls down a ravine whose upper portion is very steep and narrow; it widens, however, as it descends, and presents a succession of bluffs and flats, which extend to twenty-five yards in breadth. The bluffs hang perpendicularly over the stream. At the mouth of Monroe Run, Savage River is only thirty-three yards wide, and a dam might easily be thrown across to form a reservoir.

This passage is the only one which leads from the valley of Savage River to that of Deep Creek.

We shall now examine those which connect the valley of Crabtree Creek and Deep Creek. The first lies between the middle fork of Crabtree Creek and the Meadow Mountain Run, and would require a tunnel running under the Little Backbone and Hoop-pole Ridge. Supposing its bed on a level with the base-mark, and an open cut to the depth of 35 feet through the height, the tunnel would extend three miles 1,333⅓ yards in length. From its eastern extremity to Crabtree Creek, in following the windings of the middle fork, the descent is 1,012 feet on a distance of six miles 1,333⅓ yards; and from the mouth of the middle fork to the mouth of Savage River, in the Potomac, the descent is 420 feet on a distance of six miles 685 yards. The height of the ridge above the level of the tunnel would be 210 feet, and the ravine of middle fork differs little from that of Monroe Run. Its general breadth is about 27 yards and its banks are rugged. The whole distance from the base-mark to the mouth of Savage River would be, by this passage, nineteen miles 915 yards.

Three passages run through the Little Backbone from three branches of North Glade Run, a tributary stream of Deep Creek, to the valley of Crabtree Creek.

The first opens on the western branch of the middle fork, and would require a tunnel through the Hoop-pole Ridge. Supposing its bed on a level with the base-mark, and an open cut to the depth of 35 feet through the height, the tunnel would extend three miles 125⅓ yards in length, and the greatest height of the ridge above its bed would be 144 feet.

From the second branch of North Glade Run a passage might be opened to the eastern branch of the middle fork by a tunnel of the same nature and on the same level as the former. It would extend three miles and 83 yards in length, and the greatest height of the ridge above its bed would be 184 feet. But from its eastern extremity there would be a descent of 230 feet on a distance of one mile 366 yards.

From the third branch a passage might be opened to Rock Camp Run by a tunnel four miles in length. The greatest height of the ridge above its bed would be 222 feet; but from its eastern extremity to Crabtree Creek the descent would be 728 feet on a distance of two miles 166⅔ yards, and through a very narrow, rugged, and precipitous ravine. The north fork of Deep Creek rises near the summit of the Little Backbone at Whitsall's Springs, 105 feet above the base-mark. The spring of Savage Lick Run, a tributary stream of Crabtree Creek, rises opposite to it. A tunnel which would join them, with its bed on a level with the base-mark, and an open cut through the height

at each of its extremities to the depth of 35 feet, would extend two miles 1,083 yards in length. From its eastern extremity to Crabtree Creek the descent would be 452 feet on a distance of two miles and 100 yards, and the greatest height of the ridge above its bed would be 148 feet.

Three more passages have been surveyed between the tributaries of the north fork and those of Crabtree Creek.

The first unites Hinch's Arm to Glade Road Run by a tunnel one mile 1,166 yards in length on a level with the base-mark. The distance from its eastern extremity to Crabtree Creek is 1,500 yards, and the greatest height of the ridge above its bed 205 feet.

The two others unite Dry Arm and Dewickman's Arm with small ravines of Crabby's Arm, a tributary stream of Crabtree Creek, which rise opposite to them. The tunnel which would be required at Dry Arm would extend one mile 916 yards in length, and the greatest height of the ridge above its bed would be 271 feet. The tunnel of Dewickman's arm would extend one mile 683⅓ yards in length and the greatest height of the ridge above its bed would be 227 feet. These two tunnels, on a level with the base mark, are the shortest of those that we have enumerated on any of the designated routes of the canal.

Two passages have been surveyed and leveled to open a communication between Crabtree Creek and the Little Youghiogheny, the one from Crabby's Arm and the other from Wilson's Fork to the latter stream. They would each require a tunnel. Supposing its bed on a level with the base-mark, the tunnel from Crabby's Arm would extend three miles 1,538 yards, and the tunnel from Wilson's Fork four miles 300 yards in length, with an open cut at each of their extremities to the depth of 35 feet. The greatest height of the ridge above the bed of the tunnel from Crabby's Arm would be 444 feet, and above that of Wilson's Fork 253 feet. The distance from their eastern extremities to Swan's Mill would be two miles, with a fall of 114 feet. From Swan's Mill to the mouth of Crabtree Creek the descent would be 940 feet on a distance of seven miles 966 yards; from the mouth of Crabtree Creek to that of Savage River, on the Potomac, the distance five miles 880 yards, and the descent 378 feet. Thus from the eastern extremity of the tunnel to the mouth of Savage River, the total descent is 1,432 feet on a distance of fifteen miles 86 yards, and of these two tunnels the one by Crabby's Arm is the shortest.

Other passages have also been examined to open communications between Deep Creek and the waters of the Little Youghiogheny. The bed of the tunnels required for this purpose was fixed 17 feet above the level of the base-mark. One of these tunnels joined Westlick Run to one of the branches of the South Fork of Deep Creek. Its length was two miles 583⅓ yards, and it required a deep cut on the side of Westlick Run of the length of one mile 600 yards, and another on the side of South Fork of the length of two miles 50 yards. Another tunnel might join the Little Youghiogheny itself to South Fork. It would extend one mile 1,300 yards in length, and require an open cut of one mile 1,566⅔ yards in length toward the Little Youghiogheny, and two miles 300 yards toward the South Fork. The height of the ridge above the first tunnel would be 143 feet, and above the second, 188 feet.

Such are the chief passages through which a communication might be opened between the waters which descend from the eastern and western sides of the Little Backbone.

In recapitulating the several routes by which the canal may be directed through them, we will observe that they all extend from the mouth of Savage River, either by the valley of that stream or Crabtree Creek, to the base-mark on the bridge of Deep Creek, and that the descent or fall of the canal by all these routes is 1,432 feet.

1st. The first ascends by Savage River, Monroe Run, Meadow Mountain Run, and Deep Creek. Its total length, from the mouth of Savage River to the base-mark, is twenty-one miles 325 yards. The length of the tunnel which it requires through the ridge is five miles 833⅓ yards, and the height of the ridge above its bed, 213 feet.

2d. The second ascends by Savage River, Crabtree Creek, Middle Fork, Meadow Mountain Run, and Deep Creek. Its total length is nineteen miles 915 yards. The length of the tunnel which it requires through the ridge is three miles 1,333⅓ yards, and the height of the ridge above its bed is 210 feet.

3d. The third ascends by Savage River, Crabtree Creek, Middle Fork, the western branch of the same fork, North Glade Run, and Deep Creek. Its total length is twenty miles 1,128 yards; the length of the tunnel which it requires through the ridge three miles 125 yards, and the height of the ridge above its bed, 144 feet.

4th. The fourth ascends by Savage River, Crabtree Creek, Middle Fork, the eastern branch of the same, North Glade Run, and Deep Creek. Its total length is twenty miles 1,306 yards; the length of the tunnel which it requires through the ridge, three miles 83 yards; the height of the ridge above its bed, 184 feet.

5th. The fifth ascends by Savage River, Crabtree Creek, Rocky Camp Run, North Glade Run, and Deep Creek. Its total length is nineteen miles 630 yards; the length of the tunnel which it requires through the ridge, four miles, and the height of the ridge above its bed, 222 feet.

6th. The sixth ascends by Savage River, Crabtree Creek, Savage Lick Run, North Fork, and Deep Creek. Its total length is twenty-one miles 435 yards; the length of the tunnel which it requires through the ridge, two miles 1,083 yards, and the height of the ridge, above its bed, 148 feet.

7th. The seventh ascends by Savage River, Crabtree Creek, Hinch's Arm, Glade Road Run, North Fork, and Deep Creek. Its total length is twenty-one miles 1,158 yards; the length of the tunnel which it requires through the ridge, one mile 1,166 yards, and the height of the ridge above its bed, 205 feet.

8th. The eighth ascends by Savage River, Crabtree Creek, a ravine of Crabby's Arm, Dry Arm, North Fork, and Deep Creek. Its total length is twenty-one miles 1,368 yards; the length of the tunnel which it requires through the ridge, one mile 916 yards; and the height of the ridge above its bed, 271 feet.

9th. The ninth ascends by Savage River, Crabtree Creek, a ravine of Crabby's Arm, Dewickman's Arm, North Fork, and Deep Creek. Its total length is twenty-one miles 718 yards; the length of the tunnel which it requires through the ridge, one mile 683½ yards and the height of the ridge above its bed, 227 feet.

From the base-mark the localities of the ground leave us a choice between three routes to the mouth of Bear Creek.

The first runs by Deep Creek, Buffalo Marsh Run, Rocklick Run, a tributary stream to the western branch of Bear Creek, that western branch to its mouth in Bear Creek, and Bear Creek itself to the Youghiogheny. This route crosses, by a tunnel, the ridge which divides the heads of the western and eastern branches of Bear Creek. This tunnel beginning at McHenry's, and with an open cut of the depth of 35 feet at its southern extremity, near McHenry's, and at its northern extremity, would extend about two miles in length, and the greatest height of the ridge above its bed, supposed on a level with the base-mark, would be about 170 feet. The whole ground along this route, except where it passes through the gap of Winding Ridge, is of a soft, and good quality; and its whole length, from the base-mark to the mouth of Deer Creek, would be only twelve miles.

A second route might turn round the west of Marsh Mountain, and wind about Panther's Point. It would then turn successively round the heads of the ravines of Hoy's Run, Steep Run, Sang Run, Gap Run, and descend along Friend Run, a tributary of the western branch of Bear Creek. This route is very circuitous, and in winding round Panther's Point runs through a rocky and difficult ground. It would only be shortened by running an aqueduct 250 feet high, and above a quarter of a mile long, through the western branch of Hoy's Run, or a tunnel half a mile in length from that western branch to the head of Steep Run. The height of the ridge above the bottom of that tunnel would be about 250 feet. A level was also run over a bend of ground at Hoy's Pine Bottom to endeavor to shorten it and avoid the winding round of Panther's Point, but to run the canal over this line would require a deep cut of 1,431 yards in length, and of the depth of 99.06 feet, at the highest point of the ridge. The total length of this route would be twenty-four miles.

The third route, descending the valley of Deep Creek from the base-mark, might follow the eastern shore of the Youghiogheny to the mouth of Bear Creek, crossing successively on aqueducts Hoy's Run, Steep Run, Sang Run, Gap Run, Bear Creek, and the smaller tributary streams of that river. The ground along this route is rocky and difficult for one mile and three-quarters from Deep Creek to Hoy's Run; then light and easy for four miles to Gap Run; then rocky for the space of six miles, following the western bank of Winding Ridge; then for two and a quarter miles light and easy to the mouth of Bear Creek. The total length of this route would be twenty miles.

We have not mentioned a fourth route, which, from the base-mark, running by a tunnel through Negro Mountain, might unite Deep Creek with the eastern branch of Bear Creek, because it would require a tunnel of eight miles in length, and that the height of the ridge above its bed would be from 400 to 500 feet in the most elevated portion. The length of this route would also pass twenty miles.

Such are all the routes which lead from the valleys of Savage River and Crabtree Creek, in passing by that of Deep Creek to the mouth of Bear Creek, in the Youghiogheny. We must now examine those which, departing from the head of Crabtree Creek, reach the same point in passing by the valleys of the Little and Great Youghiogheny.

For this purpose the canal should follow the valley of Savage River from the mouth of that stream, and ascend along Crabtree Creek till it reaches two miles above Swan's Mill, where opens the eastern extremity of the tunnel of Crabby's Arm, mentioned on page 27 as the shortest of those by which Savage River can be connected with the Youghiogheny. Passing through that tunnel it would descend the valleys of the Little and Great Youghiogheny, winding along their eastern sides. When it reaches the mouth of Deep Creek it may follow one of these three directions:

1st. Ascend Deep Creek and Buffalo Marsh Run, following the first of the three routes which we have just indicated for passing from the base-mark to the mouth of

Bear Creek. This route, as we have seen, presents a tunnel two miles in length. The total distance over which it runs is as follows:

	Miles.	Yards.
From the mouth of Savage River to the east extremity of the tunnel of Crabby's Arm	15	86
From thence to the mouth of Deep Creek	22	426
From thence to the mouth of Buffalo Marsh Run	6	...
From thence to the mouth of Bear Creek	11	440
Total distance from the mouth of Savage River to that of Bear Creek	54	952

This route would present two tunnels, one three miles 1,538 yards in length at Crabby's Arm, and the other two miles in length between Buffalo Marsh Run and Rocklick Run; total, nearly six miles of tunneling.

2d. The canal might cross Deep Creek and follow the second route indicated for passing from the base-mark to Bear Creek, by winding round Panther's Point, and the heads of the ravines of Hoy's Run, Steep Run, Long Run, Gap Run, and Friend Run to the western branch of Bear Creek. Its total length would be:

	Miles.	Yards.
From the mouth of Savage River to that of Deep Creek, as above	37	512
From thence to Bear Creek	17	660
Total length	54	1,172

This route presents only one tunnel, of the length of three miles 1,538 yards, or nearly four miles, at Crabby's Arm. It may also be shortened, as mentioned above, by an aqueduct one-fourth of a mile in length and 250 feet high, or a tunnel one-half mile in length, with 250 feet of height of ridge above its bed.

3d. The canal might fall on this third route indicated above, after crossing Deep Creek, by keeping along the eastern side of the valley of the Youghiogheny, and crossing its tributaries on aqueducts. Its total length would be as follows:

	Miles.	Yards.
From the mouth of Savage River to that of Deep Creek, as above	37	512
From thence to Bear Creek	13	660
Total length	50	1,172

This route would require, like the preceding one, one tunnel, of three miles 1,538 yards, or nearly four miles in length.

From the comparison of these three routes it is evident that the second is preferable to the first. Their length is nearly the same, but the first requires six miles of tunneling and two tunnels, while the second requires only one tunnel, of something less than four miles in length. The third is shorter again, by four miles, than the second, and passes by the same tunnel. Aqueducts must be constructed on this route to cross Hoy's Run, Steep Run, Sang Run, Gap Run, and Bear Creek, but by the successive dropping of its levels they will require but a small elevation, and the waters of these runs and of the Great Youghiogheny may be raised and used to feed the canal, an advantage which the other routes do not offer. It should also be observed that these runs are not above 200 or 300 feet wide at their mouths, in the Youghiogheny. The third route is therefore preferable to the two others, on the hypothesis of uniting the mouths of Savage River and Bear Creek through the valleys of the Little and Great Youghiogheny.

We will now compare this route, which we will call the Youghiogheny route, with those which lead from Crabtree Creek to Deep Creek.

Nine routes, which all unite at the base-mark, have, as we have stated before, been examined for this purpose. Their length varies only from nineteen to twenty-two miles, but their tunnels present a much greater difference. The longest extends five miles 833⅓ yards, or about five and a half miles; and the shortest, one mile 683⅓ yards, or about one and one-third miles in length. The last should certainly be preferred. Its whole length is twenty-one miles 718 yards; and the greatest height of the ridge above its tunnel is 227 feet. We shall call it Dewickman's Arm route.

We have also observed that there are three routes from the base-mark to the mouth of Bear Creek. The first runs twelve miles by Buffalo Marsh Run and Rock Lick Run. It is the shortest, but requires two miles of tunneling. Were it not for this obstacle it offers a favorable ground for digging the canal. The second, winding round Panther's Point and the heads of Hoy's Run, Steep Run, Sang Run, Gap Run, &c., is twenty-four miles long, and is objectionable, not only for its length, but from the difficulties which it presents in turning Panther's Point. The third, by the valleys of Deep Creek and of the eastern branch of the Youghiogheny, is twenty miles long. It is shorter by four miles than the second, and requires no tunneling. In this respect it is superior to the first; for two miles of tunnel costs more than eight miles of canal,

which is the difference of their length. The passage of an active trade will also meet with more delay on a tunnel of two miles, unless its dimensions are very large, than on four or six miles of canal. This route possessing, besides, over the two others, the advantage of feeding the canal below the mouth of Deep Creek, by raising the waters of the Great Youghiogheny and its tributaries, is preferable to them in all respects.

If we add the twenty miles of this route to the twenty-one miles 718 yards of Dewickman's Arm route, we shall have for the whole length of the canal, passing along Crabtree Creek, Deep Creek, and the valley of the Youghiogheny, forty-one miles 718 yards, with one tunnel one and a third mile in length, and the height of the ridge above it 227 feet. We shall call this route Deep Creek route, in opposition to the Youghiogheny route.

To decide between these two routes, which alone can enter in competition, we must compare their length, and the time, expense, difficulties, and trouble of their construction, viewed in a general manner.

The length of the Deep Creek route is forty-one miles 718 yards; that of the Youghiogheny route fifty miles 1,172 yards. The former is, therefore, shorter by nine miles than the other.

The tunnel from Dewickman's Arm on the Deep Creek route is one mile 683⅓ yards in length, and the height of the ridge above its bed is 227 feet. The tunnel between Crabby's Arm and the Little Youghiogheny, on the Youghiogheny route, is three miles 1,533 yards in length, and the height of the ridge above its bed is 464 feet. The former requires two miles 855⅔ yards less of tunneling, and the height of the ridge above the bed of its tunnel is 237 feet less. With respect to the expense of tunneling, the route by Deep Creek is, therefore, preferable to the other.

As to the deep cuts at each extremity of these tunnels, the deep cut at the western extremity of the tunnel toward the Little Youghiogheny is two miles 930 yards in length. The deep cut at its eastern extremity, toward Crabby's Arm, is 900 yards. The whole deep cutting on the Youghiogheny route is thus three miles 70 yards.

The deep cut at the western extremity of the other tunnel toward Deep Creek extends five miles 1,096 yards. The deep cut at its eastern extremity toward Dewickman's Arm, 572 yards. Total, five miles 1,668 yards.

The Youghiogheny route will therefore require two miles 1,598 yards less of deep cutting than the other at the extremities of its tunnels. But this advantage is not to be weighed with the expense of two miles 855 yards more of tunneling.

In comparing the nature of the soil on each of these routes, and the obstacles which it may present, it must be remembered that their eastern portion, from Savage River to Crabby's Arm, and their western portion, from the mouth of Deep Creek to that of Bear Creek, are the same. In the intermediate space the ground is equally favorable and easy to work on both routes.

On the whole comparison of their respective lengths, of the time necessary to pass through the one or the other of the obstacles which they meet, and the expense and probable trouble of their construction, we believe the Deep Creek route preferable to the route by the Youghiogheny.

Our next task must be to compare the supplies of water which the canal may receive on either of these routes, and this will lead us to a detailed investigation of the resources which are offered by the water-courses of the country to feed the middle section and summit-level of the proposed canal.

Savage River and its tributary, Crabtree Creek, may feed the eastern branch of the middle section, and the Great Youghiogheny its western branch. The summit-level must draw its resources from Deep Creek, and the heads of the Little and Great Youghiogheny.

These streams were all gauged in 1824, at their lowest stage. We will give, in a general manner, the result of these operations, the minimum, in cubic feet of water, that flows through each stream in a second.

EASTERN BRANCH OF THE MIDDLE SECTION.

	Cubic ft.
Savage River gave on the 28th September below the mouth of Crabtree Creek, in a second	17.73
Savage River gave on the 28th September at its mouth, (it had, however, rained this day)	46.09
Savage River gave on the 2d September below Monroe Run	28.62
Monroe Run gave on the 28th September at its mouth	0.88
Monroe Run gave on the 16th September at its mouth	2.28
Crabtree Creek gave on the 14th September at Swan's mill	0.97
Middle Fork gave on the 15th September at its mouth in Crabtree Creek	0.84
Rock Camp Run gave on the 2d September at its mouth in Crabtree Creek	0.12
Savage Lick Run gave on the 14th September at its mouth in Crabtree Creek	0.33
Crabby's Arm gave on the 17th August at its mouth in Crabtree Creek	0.24
Wilson's Fork gave on the 17th August at its mouth in Crabtree Creek	0.35

If we consider that the water consumed in the lockage of this branch is supplied from the summit-level, these streams, turned into reservoirs by dams thrown across the tributaries of Crabtree Creek and Savage River, above the mouth of that creek, will serve to supply its losses from filtrations and evaporation. Between the mouth of Crabtree Creek and the Potomac, on a distance of five and one-half miles, Savage River, which gives 17.73 cubic feet in a second at its lowest stage, will serve for this purpose. In the remaining nine and one-half miles from the tunnel to the mouth of Crabtree Creek the Middle Fork gives 0.84 cubic foot; Rock Camp Run, 0.12 cubic foot; Savage Lick Run, 0.33 cubic foot; and Crabtree Creek itself, 0.97 cubic foot, at Swan's mill, at their lowest stages; total, 2.26 cubic feet. Reservoirs may besides be formed in the Middle Fork, Savage Lick Run and Rock Camp Run. Filtrations may also be prevented, in a great degree, by a careful construction of the bed of the canal; and from observations taken in the summer of 1824 the loss from evaporation did not exceed the quantity received by summer rains. It may also be observed that any deficit will prove to be amply supplied by the waters of the summit-level.

From the mouth of Savage River the canal may be supplied from the North Branch of the Potomac, which, on the 18th September, gave 106 cubic feet in a second; and a great reservoir may be formed in it above the mouth of Savage River. From this point, therefore, it needs no longer the waters of Savage River nor of its tributaries. And if we except the waters required for its lockage, which will be supplied from the summit-level, this branch of the middle section may be fed, in a great degree, by the streams which fall into it.

WESTERN BRANCH OF THE MIDDLE SECTION.

This portion of the canal begins in Deep Creek, five miles below the base-mark, and ends at the mouth of Bear Creek. The length is fourteen and three-fourths of a mile, and like the former branch it will receive from the summit-level the waters required for its lockage

Hoy's Run, Steep Run, Sang Run, and Gap Run may be employed to feed it and repair its losses; but these streams have not been gauged. They may, nevertheless, offer some resources for reservoirs. Bear Creek may also form a great reservoir, by damming its valley and feeding the western section of the canal, but cannot feed the western branch of the middle section, from the difference of their levels.

Deep Creek is the only stream of any importance whose waters may supply the losses of this branch from filtrations and evaporations. We should, therefore, examine accurately the means which it offers for this purpose. Its usual depth under the bridge is 3 feet; but in its freshets it rises to 12 feet. High freshets generally occur in this stream twice or thrice a year, and last from three to four days; when the rains last so long, it gives during that time from 400 to 500 cubic feet a second. During the most unfavorable season it still has freshets, less considerable, but which, nevertheless, give it a mean discharge about 100 cubic feet in a second each time; these occur from six to eight times a year. In the dryest months it gives, under the bridge, from 10 to 5½ cubic feet a second; on the 27th August, 1824, it gave 5.12 cubic feet, which was the lowest quantity we ever found.

Supposing a dam erected across Deep Creek, at the head of its rapids, and five miles below the base-mark, its basis would be 19½ feet below that mark; its length would be 136⅔ yards, and to raise its waters 4 feet above the base-mark its height should be 23½ feet. This dam would raise the waters of Deep Creek so as to overflow an area of 948,924 square yards, from accurate surveys. The prism of this reservoir, comprised between its surface and a horizontal plane, run three feet below the base-mark, would be 7 feet high, and contain in capacity 2,214,156 cubic yards. In less than three months of the rainy season, if we allow only 9 cubic feet, or one-third of a cubic yard, a second to the average supply of Deep Creek, this reservoir would be filled. It would be filled in less than five months in summer if the stream yielded at the rate of 5 cubic feet. Thus, every year, and for nine months of navigation, from the middle of March to the middle of December, we may depend on a supply equal to twice the capacity of this basin, or 4,428,312 cubic yards. This is equivalent to 492,034 cubic yards a month, and supposes only a mean supply of 5½ cubic feet a second. This is the minimum of what Deep Creek can supply to repair the losses of the western branch of the middle section from filtrations and evaporations. To ascertain its sufficiency, we must examine next what those losses may amount to.

The length of this section is fourteen and three-quarter miles. Supposing it 5 feet deep, 28 feet broad at the bottom, and 44 feet at the surface of the water, the prism of its capacity will have a base of 20 cubic yards, on a length of fourteen and three-quarter miles, equal to a cube of 519,200 cubic yards. This will be filled in the first days of March without deranging the economy of water which we have just analyzed. We have already observed that Deep Creek may supply every month a cube nearly corresponding to this, or 492,034 cubic yards, at the minimum rate, and lowest state of its

flow; we must now examine whether this supply will suffice every month to the filtrations and evaporations of fourteen and three-quarter miles of canal.

Without entering into minute calculations which properly belong to the report accompanying the final project of the canal, we will state generally the most positive results which experience has given as to the joint amount of filtrations and evaporations. Having ascertained that no experiments of this nature have been tried on the Erie Canal, where the supply of water was found evidently more than sufficient, we were obliged to consult the results of those canals constructed in Europe, under a climate which, in the summer, comes nearest to our own. We have selected for this purpose the canal of Narbonne, in the south of France. Narbonne and Baltimore, compared as to climate and rain, are as follows:

Narbonne, latitude north 43° 11′, (from observations made during twenty years.) Mean greatest heat, 95°; mean temperature, 60°; mean greatest cold, 24°; mean quantity of rain, 29.30 inches.

Baltimore, latitude north 39° 17′, (from observations made 1817–1822, by Mr. Lewis Brantz, of Maryland.) Mean greatest heat, 94°.54; mean temperature, 52°.23; mean greatest cold, 0°.12; mean quantity of rain, 38.60 inches.

Of all such works the canal of Narbonne has given most trouble to its engineers, from its excessive filtrations and loss of water in the gravelly soil through which it is run. It is a branch from the canal of Languedoc to the city of Narbonne, three miles in length. As soon as it was opened, in 1788, it lost the value or contents of its prism in a few days and overflowed the surrounding country; in 1789 it still lost the value of its prism in six days; and in 1800 it lost it in eighteen days, or the value of its prism and two-thirds every month—sixteen and two-thirds times its contents in ten months' navigation. This evaluation is the result of careful and accurate observations; and, considering the climate and soil through which this canal runs, it may fairly be taken as a specimen of the maximum loss which a canal can suffer through filtrations and evaporations.

The ground through which runs the western branch of our middle section is of a quality far superior to the country through which runs the Narbonne Canal. It is, for six and one-fourth miles, of an excellent quality; the remaining eight and one-half miles run through a rugged and rocky soil, but clay is everywhere at hand to puddle the bed of the canal, if necessary. Supposing, therefore, that its losses from filtrations and evaporation equaled in one month the cube of its prism, or 519,200 cubic yards, this would certainly be their maximum, while the evaluation of 492,034 cubic yards of water, which we have given as the supply from the reservoir of Deep Creek in one month, is its minimum. For it must be remembered that we valued this supply from the lowest result, obtained at the lowest stage of Deep Creek, when it gave only five and one-eighth cubic feet in a second.

We have allowed no loss for the evaporation for the surface of the reservoir, as it will be compensated by the frequent rains which fall on the summit of the Allegheny. For observations made in July, August, September, and October, 1824, in the valley of Deep Creek, we have ascertained that there fell, from 19th to 30th July, four days of rain, 4.36 inches, 55° mean temperature; from 1st to 31st August, eight days of rain, 2.31 inches, 63° mean temperature; from 1st to 30th September, twelve days of rain, 3.15 inches, 51° mean temperature; from 1st to 31st October, nine days of rain, 3.19 inches, 44° mean temperature; from 19th July to 31st October, thirty-three days of rain, 13 inches, 10° mean temperature. During one hundred and four days, of which thirty-three were rainy, there fell 13.01 inches of rain. The evaporation was 0.10 inch a day, and during the one hundred and four days, 10.40 inches; of course the rain more than supplied the loss of evaporation.

The temperatures marked above are the mean temperatures of the rainy days. The highest temperatures in that valley, during these months, were at midday; in July, 76°; in August, 74°; in September, 70°; in October, 72°. The lowest were at 6 in the morning; in July, 53°; in August, 44°; in September, 32°, and in October, 25°. From these observations it is evident that less evaporation is to be apprehended in the valley of Deep Creek than in regions more to the level of the ocean; besides, by raising the dam which forms its reservoir, we might add to it a quantity of water sufficient to supply all the loss of its evaporation and filtration. We will conclude these remarks on the reservoir of Deep Creek by observing that its surface lies below the mouths of its tributaries, and that they might, therefore, at small expense, be turned into reservoirs to preserve the waters of the valley, when (the great reservoir of Deep Creek being full) they would otherwise escape over the dam. For this purpose, the dams of these small streams should have sluice-gates, to distribute their supplies whenever required.

SUMMIT-LEVEL OF THE MIDDLE SECTION.

From these observations it is evident that the eastern and western branches of the middle section possess sufficient supplies to repair their losses from filtrations and evaporation. The first is fifteen, and the second fourteen and three-fourths miles in

length; and both, twenty-nine and three-fourths miles. If we subtract this length from that of the whole Deep Creek route, forty-one miles 718 yards, there will remain eleven miles 1,158 yards, or about eleven and three-fourths miles. If we subtract it from the length of the Youghiogheny route, (fifty miles 1172 yards,) there will remain twenty miles 1,580 yards, or about twenty-one miles. These portions, on either of these routes, may be designated as their summit-levels. On the Youghiogheny route this portion might, perhaps, be dropped below the reservoirs of the Youghiogheny; but its length and expanse of water, which is our present object, would remain the same on either level. We should now examine, first, what means exist to feed these summit-levels; second, what each of these requires to supply all its wants and losses; third, what are the respective advantages of the one and the other, and which is the most advantageous with respect to that question.

The Great and Little Youghiogheny and their upper tributaries are the only streams of any importance which can feed either of these summit-levels. Their levels with respect to the base-mark, and at different points, are as follows:

	Feet.
Level of the Great Youghiogheny, at the mouth of Deep Creek, below the base-mark	250.00
Level of the Great Youghiogheny, at the head of Swallow Falls, below the base-mark	140.81
Level of the Great Youghiogheny, one mile above the mouth of Indian Run, below the base-mark	70.50
Level of the Great Youghiogheny, two miles above the mouth of Indian Run, below the base-mark	64.00
Level of the Great Youghiogheny, at the mouth of the Little Youghiogheny, below the base-mark	53.00
Level of the Great Youghiogheny, at the mouth of Snow Creek, two miles above the bridge, below the base-mark	36.69
Level of the Great Youghiogheny, at Charles Glade's Run, below the base-mark	28.72
Level of the Great Youghiogheny, at the mouth of Cherrytree Creek, below the base-mark	26.18
Level of the Little Youghiogheny, where it is crossed by the State-road, below the base-mark	44.00

These levels being all below the base-mark, proved that whichever summit-level we adopt we must elevate the waters of the two Youghioghenies by throwing great dams across them. The height of these dams would be lower and a less quantity of lockage required if we dropped the summit-level of the Youghiogheny route; but the length of the tunnel from Crableg's Arm, and deep cutting at each of its extremities, would then be proportionably augmented. For the sake of comparison, we have, therefore, supposed those two routes on a level. A passage was sought to open a communication between Deep Creek and the Great Youghiogheny through the opposite valleys of Indian Run and Cranberry Run. But as the sources of these runs rise 226 feet above the base-mark, and the Youghiogheny at the Indian Run lies 70.50 feet below it, a dam across the Youghiogheny, and tunnel through the Roman Nose ridge, would both be indispensably required to accomplish this object.

An attempt was also made to lead Muddy Creek, which from the west falls in the Youghiogheny to the summit-level of these routes. But to lead it to the summit-level of the Deep Creek route it would be necessary to conduct it by a long aqueduct upward of 140 feet high, and to lead it to that of the Youghiogheny, to run a feeder upward of thirty miles before it reached the mouth of Indian Run, and which would absorb by filtrations and evaporation, during its course, most of the water which it would receive. Aqueducts through the ravines which it should wind round would shorten it, but a great number of them would be required, and their construction would be very costly.

To ascertain the levels of Pine Swamp (where rise the springs of Muddy Creek of Youghiogheny, and Muddy Creek of Cheat River) and Deep Creek, a level was run to the summit of the ridge which divides the waters of the Youghiogheny and Cheat Rivers; this ridge, parallel to the Roman Nose Ridge, is called Snaggy Mountain. From this level it appeared that the point from which rise the highest springs of the two Muddy Creeks is 75 feet above Pine Swamp, and 226.77 feet above the base-mark. This result, which proved the impossibility of running the canal in this direction from the mouth of Deep Creek, proved also that a reservoir of three or four miles area might be formed in the Pine Swamp, and that being raised at least 150 feet above the base-mark, a feeder might be led from it, following the eastern ridge of Snaggy Mountain, and joining Snowy Creek, after winding round the heads of the tributaries of the Youghiogheny, from Snowy Creek to Muddy Creek. This feeder would be from eight to twelve miles long, and to form the reservoir a dam might be thrown through Muddy Creek, of the Youghiogheny, at the gap where it breaks through Snaggy Mountain.

This reservoir would afford an important supply, if those of the Little and Great Youghiogheny should prove insufficient to feed the summit-levels. We shall now enumerate and measure the capacity of these several reservoirs, and give all the necessary details of them.

Reservoir No. 1 might be formed in the main branch of the Great Youghiogheny by thowing a dam across it, above the mouth of Cherrytree Creek. It should be 40 feet high to raise the water 6 feet above the summit-level and allow to the feeder a descent of 6 inches per mile; height of its dam, 40 feet, and length of its feeder, to the dam in Deep Creek, sixteen miles. Area of the reservoir exposed to evaporation, 2,894,333 square yards; its prism, or capacity of water above the base-mark, 5,523,370 cubic yards.

No. 2 might be formed in Cherry Creek by throwing a dam across it above its mouth. The dam should be 40 feet high, and the length of its feeder sixteen miles. For this and all the following reservoirs we shall allow the same data, 6 feet water above the base-mark and 6 inches descent per mile for their feeders. Area, 1,752,000 square yards; prism, 3,170,148 cubic yards.

No. 3 might be formed on Youghiogheny, between Cherry and Snowy Creeks, by throwing a dam through it above the mouth of Snowy Creek. Height of the dam, 50 feet; length of the feeder, fourteen miles. Area, 1,475,444 square yards; prism, 2,796,518 cubic yards.

No. 4, receiving Laurel Creek and Snowy Creek, might be formed by throwing a dam across the latter above its mouth. Height of its dam, 50 feet; length of its feeder, fourteen miles. Area, 3,444,444 square yards; prism, 6,536,666 cubic yards.

No. 5 might be formed in the Great Youghiogheny, between Snowy Creek and the Little Youghiogheny, by throwing a dam across it above the mouth of the Little Youghiogheny. Height of the dam, 67 feet; length of the feeder, ten and a half miles. Area, 2,833,332 square yards; prism, 5,555,555 cubic yards.

No. 6 might be formed in the Little Youghiogheny by throwing a dam across its mouth. Height of the dam, 67 feet; length of the feeder, eleven miles. Area, 53,375 square yards; prism, 106,750 cubic yards.

No. 7 might be formed in Dunker's Lick, by throwing a dam across it, above its mouth. Height of the dam, 75 feet; length of the feeder, nine miles. Area, 1,055,555 square yards; prism, 1,851,851 cubic yards.

No. 8 might be formed in the Great Youghiogheny, between the mouth of the Little Youghiogheny and the ledge, by throwing a dam across the ledge. The height of this dam, 94⅔ feet; length of the feeder, six and a half miles. Area, 2,770,666 square yards; prism, 5,303,555 cubic yards. Areas of all the reservoirs, 16,279,149 square yards; prism of all the reservoirs, 30,844,413 cubic yards.

If we dispense with the two last reservoirs, whose dams are the highest and most expensive, the five remaining reservoirs above the mouth of the Little Youghiogheny will contain: Area exposed to evaporation, 12,452,928 square yards, or $4\frac{2}{100}$ square miles, or 2,572.20 acres. Prism of their waters, 6 feet above the base-mark, besides 6 inches allowed per mile of the length of the feeder of each reservoir for its descent. These are all available to supply the summit-level 23,689,007 cubic yards.

These reservoirs are all independent of one another, and the higher ones may pour the surplus of their waters into the lower ones. Those numbered 3 and 5 in the Great Youghiogheny may be regarded as one, to which all the others can contribute when circumstances require it. The dam No. 3 might even be suppressed, which would reduce the number of dams to 5, but the proper location of these dams, as also their number and dimensions, will receive further investigation, which belong to the final project; their number will likely be reduced.

As to the total quantity of water which these basins might hold, if we suppose their main depth 16 yards, and a middle horizontal section run between the surface and bottom, equal in area to one-half of the upper surface, or to 6,226,464 square yards, (half of 12,452,928 square yards,) it will amount to 99,623,424 cubic yards, or, in round terms, 100,000,000 cubic yards.

As to the time necessary to fill them, from observations taken with care, from 1817 to 1824, inclusive, by Mr. Lewis Brantz, in the vicinity of Baltimore, Md., we have the following results: In the course of eight years, from 1817 to 1824, there fell, on a mean average, yearly, 39.89 inches. In 1822 there fell the smallest quantity. The summer was very dry, vegetation deficient, the crops of grain were short. The quantity of rain which fell that year was 29.20 inches. The greatest quantity which fell was in 1817. It amounted to 48.55 inches. Applying these data to the country round the summit-level, and using only the results of the year 1822, the rain which fell in the three first and three last months of this year amounted to 16.70 inches, while that which fell in the same months of the year 1817 amounted to 18.40 inches. These 16.70 inches are equivalent to 0.465 cubic yards. Thus, during the three first and last months of each year, there will fall at least 0.46 cubic yards of rain on each square yard of the heads of the Youghiogheny, and an area of 217,391,304 square yards would be required to collect water for filling the 100,000,000 cubic yards of the

reservoirs.* This area amounts to 70.18 square miles; and the area of the valleys of the two Youghioghenies, above their junction, and the surface of the reservoirs amounts to much more. Besides, the heads of Cheat River could, perhaps, be brought to feed the reservoirs. These reservoirs once filled, the mass of waters which lies lower than the head of the feeders will never alter, and the upper part, which feeds the summit-level, will alone require to be renewed every year. We have seen that it contains 23,689,007 cubic yards.

The least quantity of water which the Great Youghiogheny gave in 1824, under the bridge on the road from Manfield to Morgantown, was on the 21st of September, 22.58 feet in a second. The Little Youghiogheny gave, on the 20th of September 1824, at German bridge, 4.30 feet. Total given by those streams in a second, at their lowest stage, 26.88 feet.

This is the minimum which they can give to supply the reservoirs. In one month it would amount to 2,580,480 cubic yards, and supposing, what is most unlikely, that the two Youghioghenies and their tributaries should remain in this state, and give no more for six months, from May to October, it would supply the reservoirs with 15,482,-880 cubic yards; and as during the six preceding months they would have received much more, they would be full at the opening of navigation, and receive every month at least 2,580,480 cubic yards as regular tribute.

We do not consider in this calculation the loss by filtration and evaporation, for by raising the dams of the reservoirs a quantity of water would be added to them, which would overbalance it.

We must now compare those supplies, the minimum of what the heads of the two Youghioghenies can furnish, with the maximum of what either of the two summit-levels will require.

They will both require the same expense of water for lockage. We know that two lockfuls is the maximum expense for raising or lowering a boat, and eight minutes are required for its passage through a lock of 30 yards in length, 5⅓ yards in breadth, and 2⅔ yards in lift. Such a lock will contain 426.64 cubic yards, without deducting from it the draught of water of the boat, and its passage (at the maximum) will thus consume 853.32 cubic yards, or 854 cubic yards at most. Now, if the canal is navigated nine months, or two hundred and seventy days a year, at ten hours a day, and that the locks of the summit-level be kept in constant operation all that time, they might pass, allowing eight minutes for each boat, 20,250 boats, at an expense of water equal to 17,293,500 cubic yards for the nine months, or 1,921,500 cubic yards a month. This maximum of water for the expense of lockage is 658,980 cubic yards less than the minimum which the reservoirs will receive during that time.

The expense of water for lockage being 17,293,500 cubic yards, and the reservoirs containing 23,689,007 cubic yards, there will remain in reserve to supply the losses of the summit-level from filtrations and evaporations, 6,395,507 cubic yards.

The summit-level of Deep Creek, extending eleven and three-quarter miles in length, will require 413,600 cubic yards to fill it; and supposing that it loses by filtrations and evaporation the value of its prism every month, or nine times in the year, it will expend 3,722,400 cubic yards. The profile of its feeder having a supposed area of 10 square yards, and a length of ten and one-half miles, it will consume, at the same rate, 1,663,200 cubic yards. Total consumption for nine months, 5,385,600 cubic yards. Retrenching this quantity from the surplus mass of the reservoirs, there will still remain 1,009,907 cubic yards, which, after supplying all the waste of lockage and the losses of the summit-level from filtrations and evaporation, will serve as an additional supply to repair those of the eastern and western branches of the middle section.

The Youghiogheny summit-level, extending twenty-one miles in length, will lose, from filtrations and evaporation, on the same principle, 739,200 cubic yards a month, (the value of its prism,) and 6,652,800 cubic yards in nine months. It would thus absorb the whole surplus mass of the reservoirs, after the waste of lockage, and require a much greater expenditure of water than the Deep Creek summit-level.

Thus the important advantage of a greater supply of water, by a length shorter by nine miles, if a tunnel shorter by two and a half miles, under the Deep Creek route, superior to the other; though the final surveys only can settle that point, yet at this stage of our operations we would recommend that route in preference. However, the analysis which we have just concluded is a convincing proof that a canal by either of these routes over the chain of the Alleghanies, between the mouths of Savage River and Bear Creek, is perfectly practicable. The total distance from the mouth of Savage River to that of Bear Creek will be forty-one miles at least; the rise from the mouth of Savage River to the base-mark, 1,432 feet; and the fall from the base-mark to the mouth of Bear Creek, 956.35 feet; total of lockage, 2,388.35 feet.

The preparatory surveys executed on this middle section were performed by Captain McNeill, of the United States Topographical Engineers, and Mr. Shriver, assistant civil engineer, employed by the United States. The talents and activity displayed by these gentlemen and their assistants enabled the board to collect the facts on which they

rest their opinion of the practicability of this middle section, and of the best direction through which its route can be directed.

Captain McNeill was assisted in these labors by Messrs. De Russy, Cook, Trimble, Hazard, Dillahanty, Fessenden, and Williams, lieutenants of artillery, whose scientific education, imbibed in the Academy at West Point, was thus made valuable in the most efficient and useful manner to their country and to themselves. Mr. Shriver was assisted by Messrs. Jonathan Knight, John S. Williams, Freeman Lewis, and Joseph Shriver. The memoirs, surveys, and maps of these gentlemen accompany this report.

Before we conclude the article relating to this middle section, we should give an analysis of two other routes which have been proposed for leading the canal over the Allegheny; the one by ascending Will's Creek, (a stream which falls in the Potomac at Cumberland,) and descending to the Youghiogheny by the valley of Casselman's River; the other by passing from the valley of the Potomac to that of Cheat River, and thus descending to the Monongahela.

First. Two of the head springs of Will's Creek rise very near Flaherty Creek, which falls in Casselman's River, below Salisbury; the eastern is called Laurel Run and the other Shock's River. The shortest distance between Laurel Run and Flaherty Creek is one mile 756 yards. It was measured from Wilhelm's saw-mill, on Laurel River, to Engle's saw-mill, on Flaherty Creek. The first is 156 feet lower than the second. A deep cut of 333 yards long and 35 feet deep, in the highest part of it, on the side of Engle's saw-mill, a tunnel of 1,483 yards, and another deep cut 700 yards long and of the same depth as the former, on the side of Laurel Run, would be required to unite those two streams. The greatest height of the ridge above the bed of the tunnel would be 156 feet. This route offers great advantages if we only considered the shortness of the distance and tunnel; but as to the essential condition of a sufficient supply of water, it is absolutely out of the question. Flaherty's Creek, at Engle's mill, gives only 0.415 cubic foot in a second, and Laurel Run, at Wilhelm's mill, 0.600 cubic foot, (at their lowest stage in 1826.) They would only give, together, 1.015 cubic feet per second to feed the whole summit-level. The details, which we have already given in analyzing the Deep Creek River route and summit-level, are sufficient to show the impracticability of receiving a canal by the route of Flaherty's Creek with so small a supply of water.

As to the route between Shock's Fork and Flaherty's Creek, the season was too advanced to measure accurately its length, or the tunnel and deep cuts which it would require.

Their profile will be surveyed next season. This route would be longer than the other, and its summit-level should be fed by the waters of Casselman's River above Salisbury, led by a feeder to the western extremity of the tunnel. This feeder, following the eastern side of Casselman's Valley, would receive the waters of its tributaries between Salisbury and Flaherty's Creek. At their lowest stage these tributaries gave, altogether, 5 feet in a second, and Casselman's River, above Salisbury, 15.33 cubic feet; total, 20.33 cubic feet to feed the summit-level. This quantity is not considerable when we consider that, on a length of thirty miles from the summit-level to Cumberland, the canal would have to draw most of its water from Casselman's River, for Will's Creek is a torrent, which, in the greatest part of its course, gives but little water in summer. The length of this summit-level, and of the route which the canal would thus trace, are less than by Deep Creek. As to their comparative heights, no survey was made in the season of 1824 to ascertain the difference. We shall now expose the reasons why the western branch of the canal was not led through the valley of the Monongahela, (before concluding this part of our report.)

We have already seen that the valley of Cheat River, through which it would be necessary to pass to the Monongahela, is divided from the Upper Youghiogheny by a ridge whose greatest depression, at the head of the two Muddy Creeks, is 226.77 feet above the level of the base-mark. A tunnel would, therefore, be necessary to pass from the valley of the Youghiogheny to that of Cheat River.

A single inspection of the map will show that the route of the canal would be very much lengthened by running its summit-level from the heads of the North Branch of the Potomac to those of Cheat River, and that it should be raised to a much higher level than on the route of Deep Creek. There is every reason to believe that the bed of Cheat River has a more rapid descent than that of the Youghiogheny; and that, where it forces through the Laurel Hill, it is already nearly on a level with the Youghiogheny at Connellsville, for at this gap and a little above Furnace Run it begins to be navigable. Its bed is here about 150 yards wide. The highest floods in Cheat River do not rise above eight or ten feet at Furnace Run, and at its lowest stage in August and September it is very low at this place, and often fordable. Indeed, Cheat River to its junction with the Monongahela receives no stream of any importance but the Big Sandy, whose supply is constant, but in the summer is very trifling, even toward its mouth and in the lower part of its course. After descending along a rocky and very precipitous bed, Cheat River mingles its clear and limpid waters with the muddy stream of the Monongahela, whose bed and shores are all formed of alluvial soil.

The Monongahela has absolutely the same features as the Ohio; its shores are flat, but raised perpendicularly along both sides of the river to the height of 15 or 25 feet above the line of water, formed of a rich alluvial soil. They are covered by the current, and when the river rises they crumble into it and render its waters muddy. The floods of the Monongahela are considerable. At Brownsville it rises 38 feet, while at its lowest stage its depth is only from 12 to 15 inches on its highest bars. The two banks present all along a succession of flats and bluffs. The flats of one bank are generally opposite to the bluffs of the other, and the former are found where the river expands, while the latter close on its banks where it narrows. The chief tributaries of the Monongahela are on its right shore, George's Creek, below Mr. Gallatin's residence, Big Redstone, below Brownsville, and on the left Ten-Mile Creek. These streams flow constantly, but in summer give but a small quantity of water, an observation which is also applicable to many of the tributaries of the Youghiogheny.

If the western section of the Chesapeake and Ohio Canal cannot be led to the Monongahela it will at least embranch with it at McKeesport, and, perhaps, when a denser population will render it desirable, a line of junction may be drawn between Cheat River and the Valley of Youghiogheny. It would be fed by a reservoir above the gap of Cheat River and the constant springs which run from the western ridge of Laurel Hill.

WESTERN SECTION.

This section begins at the mouth of Bear Creek and ends at Pittsburgh, descending the valleys of the Youghiogheny and Monongahela to the Ohio.

From the mouth of Bear Creek to that of Casselman's River the Youghiogheny runs in a very winding course between a succession of flats and bluffs, the flats of one shore being generally opposed to the bluffs of the other, the banks high and rugged where they wind in, and flat where they wind out. The two banks present nearly the same difficulties. The right shore, however, seems the best. The distance between those portions, following the winding of the river, is about sixteen and a half miles.

Casselman's River is about one hundred yards wide at its mouth. It is a fine river, and will give a great deal of water to the canal. At the driest season it offers from 8 inches to 1 foot in depth. Before joining the Youghiogheny it receives Laurel Hill Creek.

From the mouth of Casselman's River till you reach two or three miles above Connellsville, the Youghiogheny forces through Briery Mountain and Laurel Hill, and its bed is very deep. The left bank is very high and rugged, the right somewhat less. In this space of about twenty-eight and a half miles the canal must be frequently cut in a shelf on the sides of the valley, or run on embankments supported by a wall. The river has a fall of about 16 feet at Ohiopyle Falls; it is here about 150 yards wide.

Connellsville is considered as the head of navigation in the Youghiogheny. In the driest season it has here from 8 inches to 1 foot in depth.

From Connellsville to Robstown the river winds during twenty-four or twenty-five miles. On all this extent the right bank is far preferable to the other. Except in three or four places, where you meet with bluffs, it consists of flats or gentle slopes, where the canal can be run without difficulty. As to these bluffs, they consist of schistose rock, easy to work. The only stream of any importance which joins the Youghiogheny between Connellsville and Robstown is Jacob's Creek, and it gives but little water in dry seasons. That route is also intercepted by two or three deep ravines, which the canal must cross on aqueducts

The distance between Robstown and McKeesport is about sixteen miles. Along this route the right shore remains preferable to the other; it consists of a succession of flats and spurs, which, being of a schistose nature and moderate height, will offer no considerable obstructions to the canal.

From McKeesport to Pittsburgh the right shore of the Monongahela offers a most favorable ground, except along two spaces of about a mile each, where rugged bluffs close on the river. The first is below Judge Wallis's and the field of Braddock's defeat; the second before reaching Pittsburgh. The whole distance in following the right bank of the river is, between McKeesport and Pittsburgh, from fifteen to sixteen miles. miles.

The highest floods of the Youghiogheny occur between Casselman's River and Connellsville. They rise to 18 feet. At Connellsville they rise from 12 to 15 feet. Salt-wells may be dug in its valley; coal and iron are abundant; and excellent materials for building, timber and stone, are found all along it.

The preparatory surveys of this western section were not commenced during the last season, 1824. They can alone fix the general route of the canal; they will be directed on the following bases: From Bear Creek the canal must follow the right shore of the valley, descending along the Youghiogheny; and though it is most favorable, (presenting a rugged bank only for four or five hundred yards,) when it reaches Selby sport bridge, two lines of direction may be tried, one along the right and the other along the left bank, to the old salt-works. The depth and breadth of the valleys and

ravines, which it will be necessary to cross on aqueducts, will be measured, and the location of these aqueducts and of the dams to form reservoirs will be fixed. If between Selbysport and the old salt-works the left shore presents any advantages over the other, deserving the expense and trouble of crossing twice the Youghiogheny, the location and dimensions of two aqueducts, one at Selbysport and above the old salt-works, will be determined, and a feeder led from Casselman's River to the latter.

From the old salt-works to the Ohiopyle Falls, the canal must follow the right shore, which is most favorable, and then, crossing Indian Creek on an aqueduct, continue along the same bank to the paper-mill, four or five miles south of Connellsville. It will be proper to ascertain whether its line should not leave the valley of the Youghiogheny above the Ohiopyle Falls, and, running east, gain the southern branch of Indian Creek, to rejoin the Youghiogheny by descending Indian Creek Valley.

From the paper-mill the canal should be run at a sufficient elevation above the river to leave the shore and gain, if possible, the high level which lies east of Connellsville, in order to turn round the rugged bluff below that place. From thence, following the right shore, it will reach Robstown, after crossing on aqueducts Maunet's Creek and Jacob's Creek. The localities and dimensions of these aqueducts must be determined as well as the resources which these streams may afford to supply the canal by turning them into reservoirs.

From Robstown to McKeesport, keeping along the right shore, it must cross Sedwickly Creek over an aqueduct, whose dimensions and location must be determined. As this creek has two considerable branches, they must be examined to determine whether reservoirs cannot be made in them. From McKeesport to Pittsburgh the canal will follow the right shore of the valley of the Monongahela, crossing in succession Crooked Run, Turtle Creek, and Nine Mile Run on aqueducts.

To ascertain whether from the paper-mill the right shores of the Youghiogheny and Monongahela are certainly the best, a level should be run along their valleys on the left shore, and the locations and dimensions of the dams or aqueducts which it would be necessary to run through the Youghiogheny at McKeesport, and through the Monongahela near its confluence with the Youghiogheny, in case this route was adopted, should be fixed and calculated.

It will also be essential to try whether the canal might not turn to the west of that narrow and rugged portion of the valley of the Youghiogheny where it forces its way through Briery Mountain and Laurel Hill. For this purpose a level should be run from Selbysport and some point of a proper elevation, and cross the Briery Mountain at the depression which it offers between the heads of Buffalo Marsh Run and the eastern branch of Sandy Creek. This level should then wind round the ravines of the head of the western branch of Sandy Creek till it met the Laurel Hill at the spot where it might be crossed by the shortest tunnel. When it reaches its western slope it should run northwardly along its foot, to descend by one of its ravines to the Youghiogheny, opposite the paper-mills.

On the whole, the western section of the canal, from the mouth of Bear Creek to that of the Monongahela, at Pittsburgh, offers no obstacles which may not be surmounted at a reasonable expense ; and the waters of the Youghiogheny, Bear Creek, and Casselman's River are amply sufficient to feed it. Large reservoirs may be formed in Bear Creek and Casselman's River by throwing dams across them, and on the route from Casselman's to the paper-mills, and at the mouth of the Youghiogheny in the Monongahela. The practicability of this section is out of question.

Its length will be about one hundred miles, and its descent from Bear Creek to Pittsburgh 584½ feet, as Pittsburgh is 756 feet above the level of the ocean. The investigation of the topography and water-courses of the country through which the Chesapeake and Ohio Canal should run, and the results of our preparatory surveys, obtained up to the present moment, demonstrate that this noble enterprise is practicable ; and, although we have not yet sufficient data to calculate the expense of the work, there is every probability that it will not bear any comparison with the political, commercial, and military advantages which it will procure to the Union.

The total result of the length, rise, and fall of the canal is as follows:

Total length :

	Miles.
From the tide-water, in the Potomac, to Cumberland, (from Messrs. Mone and Briggs's survey)	182
From Cumberland to the mouth of Savage River, (from report of Major Abert, United States Topographical Engineers)	27½
From the mouth of Savage River to that of Bear Creek, by the Deep Creek route, (from the surveys of Captain McNeill, United States Topographical Engineers, and Mr. Shriver, United States assistant civil engineer)	41
From the mouth of Bear Creek to Pittsburgh, (from Mr. Shriver's computation	100
	350½

Total rise:

	Feet.
From tide-water, in the Potomac, to Cumberland, (from the profile of Cumberland road)	357
From Cumberland to the mouth of Savage River, (from Major Abert's survey)	327½
From the mouth of Savage River to the base-mark on the Deep Creek summit-level, (from Captain McNeill's survey)	1,432
	2,296½

Total descent:

	Feet.
From the base-mark to the mouth of Bear Creek	956
From thence to the Ohio, at Pittsburgh	584½
	1,540½
Total lockage for rise and descent	3,837

* * * * * *

S. BERNARD,
Brigadier-General.
JOS. G. TOTTEN,
Major Engineers, and Brevet Lieutenant-Colonel.

Report of the board of internal improvement on the Chesapeake and Ohio Canal, comprising the plan and estimate of the same, October 23, 1826.

The operations which have been executed in the field, in 1824, in relation to the contemplated Chesapeake and Ohio Canal, had chiefly for object to ascertain the practicability of the undertaking. Those performed in 1825 were to determine the route to be recommended, as also to obtain the data necessary to frame a general plan of the work and a preparatory estimate of the expense.

Another series of operations remains yet to be executed: 1. To locate accurately the canal on the ground, and to fix the final site of the locks, aqueducts, culverts, dams, bridges, &c. 2. To frame for each portion of canal the plans and profiles necessary for its execution. 3. To make on the spot the calculations of excavation and embankment. 4. To draw up the estimate of each individual work according to local circumstances. 5. To prepare the proper specifications to put the work under contract. This series of operations belongs more properly to the construction than to the general plan of the canal, and may be deferred until the execution shall have been decided. These operations will then keep pace with the execution of the work, and their results for each portion will improve by the experience gradually acquired during the construction of the canal.

These considerations, the scarcity of means at our disposal at this time, and the expediency of affording a result as to this great, important national work, have induced us to limit the surveys to those strictly necessary to enable us to frame a general plan and a preparatory estimate.

In the report submitted by the board on the 2d of February, 1825, (marked A among the documents which accompanied the President's message of the 14th of February, 1825,) all the experimental lines surveyed in 1824 have been described, and mention has been made of several others which were yet to be surveyed. We have also presented, in the same report A, the considerations relative to the hydrography of the country in the general direction of the canal. We will, therefore, confine ourselves to the description of the experimental lines, which, on account of the advanced season in 1824, had been postponed to 1825; we will compare these lines to the others, and point out the route which seems to us entitled to preference.

Experimental lines.

Summit-level by Deep Creek.—In the report A, it has been anticipated that the section of canal from the tunnel at Derrickman's Arm to the mouth of Bear Creek would follow the valley of Deep Creek as far as the Rapids, then turn Panther's Point, and descend to the mouth of Bear Creek, along the left side of the Youghiogheny. However, it became necessary to compare this route with another more direct, which, following the former as far as Deep Creek bridge, would continue to Rock Lick Run, a western tributary of Bear Creek. The survey has shown that, the bottom of canal being assumed three feet above the bottom of Deep Creek at the bridge, a tunnel would

be necessary to cross the ridge which separates Buffalo Marsh Run from Rock Lick Run. The distance and descent are as follows:

Sections.	Miles.	Yards.	Feet.
From the eastern end of the tunnel at Derrickman's Arm to the base-mark at Deep Creek	6	1,048	....
Descent in this distance	....	....	000
From the base-mark to the debouch into Rock Lick Run	5	38½	....
Descent in this distance	....	....	000
From this debouch to the mouth of Bear Creek	7	535½	....
Descent in this distance	....	....	912
Total	18	1,622	912

In this total distance, two tunnels would be necessary: one at Derrickman's Arm, whose length would be 1 mile 568 yards, and whose bottom would be below the top of the ridge, 233 feet; one at Buffalo Marsh Run, whose length would be 2 miles 254 yards, and whose bottom would be below the top of the ridge 343 feet; total length of tunnels 3 miles 822 yards.

In order to remove all doubts as to the expediency of this portion of canal-route, and to lessen, as much as practicable, the length of the tunnels and the excavation at their deep cuts, a second line, 13 feet 9 inches higher than the preceding one, has been tried; the results of which are as follows:

Sections.	Miles.	Yards.	Feet.
From the eastern end of the tunnel at Derrickman's Arm to the base-mark at Deep Creek bridge	7	216	....
Descent in this distance	....	....	0
From the base-mark to the debouch into Rock Lick Run	5	38½	....
Descent in this distance	....	....	0
From this debouch to the mouth of Bear Creek	7	535½	....
Descent in this distance	....	....	925¾
	19	790	925¾

As to the length of the tunnels and the height of the ridges above the bottom of tunnels, they are respectively:

Sections.	Miles.	Yards.	Feet.
Derrickman's Arm, length	1	278	....
Height of the ridge	....	....	219¼
Buffalo Marsh Run, length	1	1,215	....
Height of the ridge	....	....	329¼
	2	1,493	....

This arrangement would lessen the length of tunnels by 1,089 yards, and also the excavation through the valley of Deep Creek by at least 1,000,000 cubic yards. But the level of this route being 13¾ feet higher than that of the former route, the volume of available water in the reservoir of Deep Creek would be much diminished, and it would also become necessary to raise, by 13¾ feet, the dams recommended (in the report A) across the Youghiogheny, in order to feed the canal; a circumstance which would increase the expense and difficulty attending the erection of these dams. It must be observed that Deep Creek alone is altogether unable to feed a summit-level, while it scarcely yields, during the dry season, 5 cubic feet of water per second. Its tributaries are liable to become entirely dry, as happened in 1825.

However, we will compare this direct route, running from Derrickman's Arm to the

mouth of Bear Creek, with that through Deep Creek and the right side of the Youghiogheny, and whose distance and descent are as follows:

Sections.	Miles.	Yards.	Feet.
From the eastern end of the tunnel at Derrickman's Arm to the base-mark at Deep Creek bridge	6	1,048	....
Descent in this distance	....	....	
From the base-mark to the western end of the summit-level	6	204⅝	....
Descent in this distance	....	....	
From the western end of the summit-level to the mouth of Bear Creek	15	100	....
Descent in this distance	....	....	912
Total	27	1,352⅝	912

On this portion of route there would be one tunnel only, (at Derrickman's Arm,) whose length, as already stated, would be 1 mile 568 yards. The distance and descent in following the direct route would be, as above, 19 miles 790 yards 925¾ feet.

The length of the two tunnels taken together would be, as above, 2 miles 1,493 yards.

The direct route would, therefore, be eight miles, 562⅝ yards shorter than the other, but it would require a greater length of tunnel by 1 mile 568 yards, and cause an increase of lockage of 27½ feet, which, as to time and expense, gives a decided advantage to the other route. Again, the descent from the debouch into Rock Lick Run to the mouth of Bear Creek is 925¾ feet, on a distance of 7 miles 535½ yards, which, on the supposition of a uniform declivity, could afford but 115 yards to the location of one lock, eight feet lift, with its adjoining pond; but this declivity is far from being uniform, and in some places it will be so rapid as to oblige to locate the locks quite close to each other, a circumstance which would involve the expense of a double set of locks. All these considerations, added to the difficulty of feeding the upper level, induce us to reject this direct route, and to give the preference to that through the valleys of Deep Creek and of the Youghiogheny, as assumed in the report A, (February, 1825.)

Summit-level by Flaugherty Creek.—But a much more important route was yet to be examined, which, having its summit-level at the source of Will's Creek, would commence at Cumberland, ascend this creek, cross the ridge which separates Will's Creek from Casselman's River, and descend the valley of this stream to debouch into the Youghiogheny at its junction with Casselman's River and Laurel Hill Run. Mention has been made of this route in report A, (pages 40 and 41.) Some experimental lines were surveyed on the summit-ground in 1824, and some measurements of water were taken; but the season being then too far advanced to prosecute further the surveys and levelings relative to this route, the board were compelled to defer their execution until 1825; and as early as the 12th of March, 1825, they framed detailed instructions respecting the surveys and investigations necessary to ascertain the practicability of a route of canal in this direction. This route deserved so much the more a careful examination that it promised, by means of a tunnel, a shorter distance, but it became necessary to ascertain, in the first instance, the minimum length of the tunnel which should receive, at its western end, water enough from Casselman's River to supply the summit-level and a portion of the canal down Well's Creek. Upon this point rested the practicability of this route. Indeed, the survey made in 1824 had tried a tunnel of 1,483 yards in length, with a greatest height of ridge of 156 feet; but the essential condition of a sufficient supply of water had not been obtained at such an elevation. It therefore remained to find out, by surveys, a tunnel combining the shortest length with a competent supply of water. These surveys were intrusted to Capt. Wm. G. McNeill, of the Topographical Engineers, who carried them, in the most able manner, into execution.

The result has been that a tunnel from the mouth of Bowman's Run, in Will's Creek, to the mouth of Flaugherty Creek, in Casselman's River, was the shortest which could be admitted to procure at the same time the other requisite as to the sufficiency of water. The length of this tunnel is 4 miles 80 yards, with a deep cut at each end; the eastern being 140 yards long, the western 1,060 yards; the greatest depth of each 35 feet, but the height of the top of the ridge above the bottom of the tunnel is not less than 856 feet.

Let us now examine the resources afforded to feed this summit-level. Casselman's River is the only stream upon which we can rely to fulfill this object. It yielded, on the 21st of June, 1825, at Plencher's farm, 12 miles above the mouth of Flaugherty

Creek, 18 cubic feet of water per second; on the 7th of the same month, it yielded at the same place 44 cubic feet per second; on the 10th of July, same year, it yielded 38 cubic feet per second, above the mouth of Flaugherty Creek. It must be observed, that in consequence of a freshet, the stream, on the 24th of June, 1825, yielded at Forney's Mill, 5 miles above Flaugherty Creek, 803 cubic feet per second; three days afterwards, it still delivered 103 cubic feet. From all these results, we adopt the smallest; and we assume 18 cubic feet as the minimum of water supplied by Casselman's above the mouth of Flaugherty Creek. Besides this supply of running water, two reservoirs can be made in the bed of the stream: one at Plencher's farm, containing 4,679,029 cubic yards; the second, below Forney's Mill, containing 17,091,490 yards; together, about 22,000,000 yards. The dam of the first would be 40 feet high, 230 yards long at the top; the foot 114 feet above the summit-level; the dam to form the other would be 50 feet high, (to obtain a height of 40 feet of available water,) and from 140 to 160 yards long at the top. The feeder from the upper reservoir to the lower one would be about seven miles; but the feeder from the lower and large reservoir to the summit-level would be 3½ miles only. The area of the reservoir at Plencher's farm will be 1,040,600 square yards; that of the great reservoir, 2,541,000 square yards; total, together, 3,581,600 square yards.

We shall, in the sequel of this report, take into more minute consideration these supplies of water; for the moment we leave the subject to present a comparison between the route of canal and that by Deep Creek, as suggested in the report A, by and in consequence of the limited facts which then it had been in our power to ascertain. The first will be designated Casselman's route, the other Deep Creek route.

The length, ascent, and descent of Casselman's route are as follows:

Sections.	Miles.	Yards.	Feet.
From Cumberland bench-mark to the eastern end of the summit-level	29	240	....
Ascent in this distance	....	....	1,325
Summit-level: eastern basin, 880 yards; eastern deep-cut, 140 yards; tunnel, 4 miles 80 yards; western deep-cut, 1,060 yards; western basin, 880 yards	5	1,280	....
From the western end of the summit-level to the Youghiogheny, 440 yards below the mouth of Casselman's River	35	1,250	....
Descent in this distance	....	....	636
Total distance and lockage	70	1,010	1,961

The length, ascent, and descent of the Deep Creek route are as follows:

Sections.	Miles.	Yards.	Feet.
From Cumberland bench-mark to the mouth of Savage River	30	350	....
Ascent in this distance	....	....	327½
From the mouth of Savage to the mouth of Crabtree Creek	5	....	....
Ascent in this distance	....	....	383
From the mouth of Crabtree Creek to the eastern end of the summit-level	8	1,430	....
Ascent in this distance	....	....	1,051
Total ascent, 1,761½.			
Summit-level: eastern deep-cut, 352 yards; tunnel, 1 mile 568 yards; western deep-cut, 5 miles 480 yards; western end, 6 miles 204⅜ yards	12	1,604⅜	....
From the western end of the summit-level to the mouth of Bear Creek	15	100	....
Descent in this distance	....	....	912
From the mouth of Bear Creek to a point in the Youghiogheny 440 yards below the mouth of Casselman's	16	1,075⅛	....
Descent in this distance	....	....	164
Total descent, 1,076 feet.			
Total distance and lockage	88	1,040	2,837½

Both summits of these routes, being compared as to altitude to the Cumberland bench-mark, will show a difference of level of 436½ feet in favor of the Casselman route. This difference would be 440 feet, if the level of comparison were assumed at the point of junction of these routes into the Youghiogheny; but as at this point no well-fixed bench-mark had been agreed to between the two surveying parties, we rely, in preference, on the former result. This important result shows that through Casselman's the lockage will be 873 feet less than through the other route.

As to distance, the foregoing statements exhibit a length of 18 miles 30 yards in favor of the Casselman route; which, combined with a less amount of lockage, gives to this route, as to time, a decided advantage over the Deep Creek route.

Let us examine now which of these routes will afford the greatest facility to the location of the locks.

By assuming 8 feet as a common lift, we find that, from Cumberland to the mouth of Savage, the average distance between the heads of the two locks will be 1,296 yards; from the mouth of Savage to Crabtree Creek, 183 yards; from the mouth of Crabtree Creek to the eastern end of the summit-level, 117 yards; and this on the supposition of a uniform declivity, which is far from being the case, and more especially in the valley of Crabtree Creek, where, toward the head, the locks, on account of the steepness of the ascent, could not even find room, unless their lift should be considerably increased. To this difficulty we must add the narrowness of the valley, which would oblige to resort to very extensive means to erect, where necessary, double sets of locks, as also to shelter the work from destruction, either by high freshets or by heavy showers.

As to the western section of this route, serious difficulty would be encountered to turn Panther's Point, the sudden fall being great and the side of the valley very precipitous. It would become necessary to descend at once about 400 feet in a distance which could hardly afford room for the location of locks succeeding closely to each other without intermediate ponds. This circumstance would either necessitate a double set of locks or oblige to stretch, at considerable expense, the line of canal around this steep spur which separates Deep Cut from Hoy's Run.

These difficulties as to the location of locks are not to be met with on the Casselmans route. In the valley of Will's Creek 200 yards will be the shortest distance between the heads of two successive locks, and in that of Casselman's 300 yards. We must also remark that, though the valley of Will's Creek becomes gradually narrower above the mouth of Little Will's Creek, yet it affords room enough for the works, and these will be more easily protected against freshets and showers than they could be in the valleys of Crabtree Creek and Savage River.

The foregoing considerations show that, in relation to a less difficult location of canal, the Casselman route has (abstraction being made, for the present, of the tunnel) a decided advantage over the Deep Creek route. But another important object is also to be examined: we mean the supply of water at the respective summit-levels.

Respecting this point, it has been seen that the resources yielded by Casselman's, above the mouth of Flaugherty Creek, consisted of 18 cubic feet per second of running water, and of two reservoirs of available stored water, amounting to about 22,000,000 cubic yards. As to the Deep Creek summit-level, it has been shown in report A (February, 1825) that Deep Creek delivered, as a minimum, 5.12 cubic feet per second, (page 32;) the Little and Great Youghiogheny together, 26.88 cubic feet per second, (page 38;) total of running water, 32 cubic feet per second.

The reservoirs in Deep Creek amount to 2,214,156 cubic yards of available water, (page 32,) and those in the Youghiogheny to 23,689,007 cubic yards together, (page 37;) total, 25,903,163 cubic yards; we assume 26,000,000. These supplies of water will compare as follows:

	Cubic feet per second.		Cubic yards.
Deep Creek summit, running water...	32	Reservoirs....................	26,000,000
Casselman's summit, running water...	18	Reservoirs....................	22,000,000
Difference in favor of Deep Creek.....	14		4,000,000

But the following remarks will attenuate this advantage and induce to place these resources upon a nearer footing: 1. Deep Creek and both Youghioghenies were gauged in 1824, whereas Casselman's River was measured in 1825, whose summer and autumn were drier than those of the preceding year. 2. The feeder destined to bring the water of the Youghiogheny reservoirs on to the summit-level of Deep Creek will be about twelve miles long, while the feeder from the great reservoir below Forney's mill will be but three and a half miles in length. Therefore the loss of water by evaporation and leakage will be for the latter the fourth of that for the former. This fact deserves so much more due attention that experience has proved positively that such losses were by far greater in feeders than in portions of canal of the same length. 3. The 18 cubic feet per second allowed to Casselman's River were gauged at Plencher's farm, 114 feet above the summit-level, and no account has been kept of the water delivered by Meadow Run, Tub

Run, Pine Run, tributaries of Casselman's, whose mouths are below Plencher's farm, and higher than the summit-level; however, they have yielded together, as a minimum, on the last days of June and first days of July, 1825, 13.84 cubic feet per second.
4. The reservoirs in the Youghiogheny present to evaporation an area of (report A, page 37) 12,452,928 square yards, while those in Casselman's present but 3,581,600 square yards; difference in favor of the latter, 8,871,328 square yards, a difference which will cause a saving of about 6,000,000 cubic yards of water, the yearly fall of rain being supposed to be but 36 inches, and the common ratio of 5 to 3 being admitted between the yearly evaporation and fall of rain upon the surface of a given reservoir.

The foregoing facts and computations lead us to the conclusion that, with respect to water-supply, both routes may be considered as on an equal footing. It remains now to compare the expense attending the construction of either route.

The lockage on the Deer Creek route is 873 feet more than on the Casselman route; to which are to be added, for double set of locks in Crabtree Creek, at least 350 feet, and at Panther's Point, at least 200 feet; total, 1,423 feet, or 178 locks, 8 feet lift, which would cost $2,136,000, at the rate of $12,000 each.

The deep cut, from the western end of the tunnel to the base-mark at Deep Creek bridge, is 5 miles 480 yards long, and has, at its eastern end, a depth of 40 feet, which diminishes gradually approaching the base-mark. The amount of its excavation will be 1,407,961 cubic yards, from which, on subtracting 87,556 cubic yards, amount of excavation for the western deep cut of the tunnel at Flaugherty, it remains 1,320,405 cubic yards to the disadvantage of the Deep Creek route. On the reasonable supposition that the ground will require, for excavating, two men, one with shovel, the other with pick, and the transportation being assumed at the distance of ninety yards for an ascent of one-twelfth, this excavation will cost $448,937.70 at the rate of 34 cents the cubic yard.

The Derrickman tunnel is 1 mile 568 yards long, and has 233 feet of height of ridge above its bottom.

The Flaugherty tunnel is 4 miles 80 yards long, and has 856 feet of height of ridge above its bottom.

Difference in favor of Deep Creek, 2 miles 1,272 yards in length, and 623 feet in height of ridge above its bottom.

The comparative cost of these tunnels will be as follows; the substance supposed to be sandstone:

Parts.	Flaugherty's.	Derrickman's.	Difference.
Shafts	$233,032 95	$17,108 99	$215,923 96
Heading	383,534 83	119,738 12	263,796 71
Side-heading	7,704 27	2,704 27	5,000 00
Tunnel	2,495,242 80	808,106 50	1,687,136 30
Draining	159,469 30	7,010 90	152,458 40
Total cost	3,278,984 15	954,668 78	2,324,315 37

Respecting the dams to be erected across the two Youghioghenies to form the reservoirs destined to supply the Deep Creek summit, they should have at least a height of 50 feet, and may be reduced to four in number. They would also measure together a length of 1,200 yards at the least. As to those across Casselman's, they may be reduced to one only below Forney's mill; its height will be 50 feet, and its length at the top 160 yards. The expense for this object will, therefore, be one and a half times as great for the Deep Creek as for the Casselman route.

The dam below Forney's mill will cost	$27,601 60
Therefore the dams across the Youghioghenies will cost together	207,012 00
Difference in favor of the Casselman route	179,410 40

Finally, the route by Deep Creek will be 18 miles 30 yards longer than by Flaugherty Creek. These eighteen miles, on the most favorable supposition of level cutting and light ground, will cost at the rate of 13.6 cents per cubic yard, digging and transportation included, $96,940.80.

Recapitulating now the extra expenses for each route, we find them as follows:

Deep Creek route.

For lockage	$2,136,000 00
For the western deep-cut	448,937 70
For the dams	179,410 40
For the 18 miles	96,940 80
Total	2,861,288 90

Casselman's route.

For 2 miles 1,272 yards of tunnel	2,324,315 37
Difference in favor of this route	536,973 53

The Casselman route will, therefore, be less expensive than the Deep Creek route; its supply of water nearly the same; its location more easy; its summit-level less liable to be encumbered at the ends; and on account of less lockage and shorter length, it will produce a saving of time of twenty-two hours. All these results combined lead us to give to the Casselman route a decided preference.

Before closing this part of our report, we must exhibit the results of an attempt made to avoid the rugged portion of the Youghiogheny, where the stream forces its way through Briery Mount and Laurel Hill. To this effect, a route was tried, which, commencing either at the fork of Bear Creek or above the Swallow Falls, in the Youghiogheny, runs through Asher's Glade, a depression of Briery Mount, thence crosses, by a tunnel, Laurel Hill, to follow afterward its western side, and debouch into the Youghiogheny, at the mouth of Dunbar Creek, one mile above Connellsville.

Mention has been made of this route in the report A, (February, 1825,) page 44. Though the single inspection of the ground had sufficiently shown that very little reliance was to be placed upon it, yet it was essential to try its degree of practicability; its surveys and levelings were, therefore, made at as long sights as the ground would admit.

The fork of Bear Creek, that is, the point where the western and eastern branches unite, has been found to be 780.93 feet below the base-mark at Deep Creek bridge, and 640.09 feet below Briery Mount at Asher's Glade; therefore, Asher's Glade is but 131.84 feet below the base-mark at Deep Creek. This fact alone shows the absolute impracticability of obtaining a line of canal in this direction. It shows, also, that whatever may be the line devised to reach Asher's Glade, it cannot be kept lower than 131.84 feet below the summit-level of Deep Creek, and must rely on the Youghiogheny alone for its supply of water; and this for its whole length, from Deep Creek to the mouth of Dunbar Creek; the resources afforded by the intervening streams being, in summer, of no consequence.

By trying a line through the left side of the Youghiogheny, we should first cross this stream by an aqueduct of more than 150 feet high, then follow the western side of the valley, to strike, in succession, the head branches of Buffalo Creek, Big Sandy Creek, and Little Sandy Creek. The line would then cross Laurel Hill by a tunnel of one and a half miles in length and 547 feet under the ridge, and thence descend to the mouth of Dunbar Creek, after having traversed deep and numerous ravines which face on the western side of Laurel Hill. It must be remarked that, from the Little Sandy to the mouth of Dunbar Creek, in a distance of about twelve miles, this route of canal would oppose difficulties which would be far greater than those to be met with in the valley of the Youghiogheny, where the stream breaks through Briery Mount and Laurel Hill. The distance from Deep Creek to Connellsville by this route would be seventy-one miles, and six miles longer than through the valley of the Youghiogheny; and if we add to the foregoing statements the deficiency of water, we must conclude that a canal following this direction is utterly inadmissible.

In conformity to an order of the Engineer Department, a leveling has been made, in March, 1826, in relation to a feeder destined to transfer the supply of Deep Creek summit to the Casselman summit. Capt. William G. McNeill, of the Topographical Engineers, to whom this duty was assigned, received from the board the necessary instructions. His report affords the following results:

Length of the feeder.

	Miles.	Yards.
From the base-mark at Deep Creek bridge to the point where the feeder meets Casselman's River	15	585
From this point to the bridge across Casselman's River on the National Road, (nearly)	8	880
Thence to the reservoir at Plencher's farm	1	880
Add the length of feeder from the dams in the Youghiogheny to the reservoir at Deep Creek	12	0
Total length	37	585

On this distance there are four deep cuts and two tunnels, viz:

	Miles.	Yards.
A deep cut terminating in Buffalo Marsh Run	2	757
Thence a tunnel to the valley of Bear Creek	5	939
A deep cut from the end of this tunnel	0	708
A deep cut at the western side of Negro Mountain	0	278
A tunnel through this mountain	1	1,640
A deep cut from the end of this tunnel	0	330
Together	10	1,132

Out of which for deep cuts, having 35 feet of greater depth, 3 miles 313 yards; for tunnels, 7 miles 819 yards.

It is fortunate that so long and so expensive a feeder can be dispensed with.

The foregoing facts and investigations, connected with those exposed in the report A, (February, 1825,) lead us to recommend the following route for the Chesapeake and Ohio Canal:

From Georgetown, D. C., to Cumberland, it will ascend the valley of the Potomac, thence the valley of Will's Creek, to the mouth of Bowman's Run. It will then cross the summit-ridge by a tunnel, and descend, in succession, the valleys of Casselman's River and the Youghiogheny, to terminate at Pittsburgh, Pa., at the mouth of the Monongahela.

We have now to present the description of the general plan of the work; but as we think it more expedient to progress simultaneously with the description and estimate, we will previously give an analysis of the main prices upon which the estimate is calculated, and point out the dimensions upon which the plan is predicated.

We observe, also, that the whole line of canal will be subdivided into three distinct sections, each of them forming of itself a separate system, viz:

Eastern section, from Georgetown to Cumberland.

Middle section, from Cumberland to the mouth of Casselman's River.

Western section, from the mouth of Casselman's to Pittsburgh.

* * * * * * *

Plan and estimate of the canal.

The transverse section of the canal is exhibited on the sheet No. 3. The breadth at the bottom is 33 feet; at the surface, 48 feet; the depth of water, 5 feet; the tow-path, 9 feet wide; the guard-banks, 5 feet at the top; the surf-berms, kept on the level of water, 2 feet wide each; the tow-path and top of the guard-bank, 2 feet above the surface of the canal.

This transverse section is to be modified where local circumstances require it, and, more especially, in the cases of deep cutting, steep side-cutting, embanking, and also where the canal is supported by walls. In the framing of the plan a due attention has been paid to these modifications, with a view to conciliate the convenience of the work with the strictest economy. The depth of 5 feet has been preserved throughout the line, but the breadth has been often much lessened. As to the surf-berms, they are intended to protect the slopes from being washed off, as also to lessen the resistance opposed to the boat by affording to the eddy-water a free passage.

We must submit, however, the reasons which led us to propose the above dimensions.

The experiments made in 1775 by the French Academicians (D'Alembert, Condaset, and Bossat) have shown—

1. That the resistance of water to the perpendicular motion of a given plane may be regarded as proportional to the square of the velocity.
2. That, the velocity being the same, the resistance of water may be considered as proportional to the area of the plane.
3. That these results obtained only in the case of an indefinite expanse of water.
4. That in narrow canals the resistance increases in a more rapid ratio than the square of the velocity.

To attenuate as much as practicable this inconvenience, researches have been made to ascertain what should be the ratio between the transverse section of the canal and the transverse section of the boat in order that the boat might move through such a canal as through an indefinite expanse of water.

Experiments made on the subject by the celebrated Chevalier Dubuat have shown

that to attain this result the cross-section of the canal ought to be, with moderate velocities, 6.46 times the cross-section of the boat, and the water-line 4½ times the breadth of the boat.

Adopting, to preserve uniformity, 13½ feet for the breadth of the boats used on the Chesapeake and Ohio Canal, (which is the breadth of the Erie Canal and of the Ohio Canal boats,) if we suppose the draught to be 3 feet, the prow to be rectangular, and the sides and bottom of the boat to conform to it, the cross-section of the boat will be 40.5 square feet. Taking, now, this area 6.46 times, we find 261⅗ square feet for the cross-section of the canal, through which the boat would not meet with a greater resistance than through an indefinite expanse of water. The water-line should be 60¾ feet; that is, four times and a half the breadth of the boat.

Were not expense to be taken into consideration, these dimensions might be recommended, but fitness of the work and strict economy must be reconciled as much as practicable, and it is in such a view that smaller dimensions are to be fixed upon.

It is to be remarked that the distance from Georgetown to Pittsburgh in following the line of the canal is three hundred and forty-one and a half miles, which, at the rate of two and a half miles per hour, will be traveled in about 136 hours. The ascent and descent, amounting together to 3,158 feet, will require, at the rate of one minute per foot, about 52 hours; distance in time from Georgetown to Pittsburgh, 188 hours. Though a number of canals, selected among those executed to this day, might afford, together, the distance and lockage found for the Chesapeake and Ohio Canal, yet there is not, within our knowledge, any line of the same extent requiring even 1,800 feet of ascent and descent taken together. The Erie Canal requires 688 feet for three hundred and sixty-two miles; the line from Liverpool to London, 1,451¼ feet for two hundred and sixty-four miles; the canal from the Rhone to the Rhine, connecting Lyons with Strasbourg, has about 1,458 feet of lockage for a length of two hundred miles. The proposed canal has, therefore, as to time, a decided inferiority when compared to a canal of the same length, but having a less amount of lockage; and it becomes, in the present case, indispensable to remedy this inconvenience. The means we propose consist in the increase of the dimensions of the cross-section of the canal, with a view to compensate by a greater weight (transported without additional power) for the virtual increase of distance caused by so great an amount of lockage.

We have shown that this section ought to be 261 square feet, with a water-line of 60 feet, to procure a boat 13 feet 6 inches in breadth the advantage of moving on the canal as on an indefinite extent of water. After many trials and minute calculations, we have concluded to adopt for the contemplated canal the four-fifths of the foregoing results, viz, for the cross-section 208 square feet, and for the water-line 48 feet; and from these data we have formed, with a depth of 5 feet, the general transverse profile of the canal, as exhibited on the sheet No. 3.

Let us now compare this profile to one having 40 feet at the surface, 28 feet at bottom, and 4 feet in depth; the boat used being the same for both, and having 13½ feet in breadth, and 3 feet in draught. We find by calculations that, the velocity remaining the same, the resistance to the boat moving in the 48-foot canal is to the resistance to the same boat moving in the 40-foot canal as 1.21 to 1.58, or as 100 to 130. Therefore, at the same rate of velocity, 100 horses will, on the 48-foot canal, perform the same work as 130 horses on the 40-foot canal; and with the same towing-power the weight transported on the 48-foot canal, will be to the weight transported on the 40-foot canal as 130 to 100.

But the depth of the 48-foot canal being 1 foot greater than the depth of the other, let us examine what will be the comparative resistance of the boat being immersed 4 feet into the 48-foot canal, and but 3 feet in the other. We find in this case the ratio to be 1.47 to 1.58, or 100 to 107, and we infer from it that, with a gain of about 7 per cent. of towing-power, the weight transported on the 48-foot canal will be one-third greater than the weight transported during the same time on the 40-foot canal.

The foregoing considerations show that in determining the transverse section of a canal of great length, and with a dividing summit-level, the amount of lockage must have a due influence upon the breadth and depth of the water-section. And, indeed, taking into view the great distance and considerable lockage belonging to the present case, a cross-section larger than that recommended might have been suggested had not a regard to economy and to a competent supply of water during the dry season forbidden it.

However, the transverse section, as just proposed, may be deemed sufficient to fulfill in a satisfactory manner the main requisite for which it has been intended. And in order to remove all doubt, let us compare as to amount of transportation the contemplated Chesapeake and Ohio Canal with another of the same length, but whose lockage would be 600 feet only, with a transverse section of 40 feet at the surface and 4 feet in depth.

The rate of traveling being supposed for both two and one-half miles per hour, and one minute allowed for each foot of lockage, 60 feet will be, as to time, equivalent to two and one-half miles, and these canals will then compare as follows:

The Chesapeake and Ohio Canal having 3,158 feet of lockage in a distance of three hundred and forty-one and one-half miles, is equivalent, as to time, to a single level canal of four hundred and seventy-three miles, which would require 189 hours to be traveled from one end to the other.

The 40-feet canal having 600 feet of lockage in a distance of three hundred and forty-one and a half miles, is equivalent as to time to a single level canal of three hundred and sixty-seven miles, and which would be traveled in 146 hours from one end to the other. But it has been shown that on the first canal the amount of transportation being expressed by 130, it will be 100 on the 40-feet canal—the velocity and towing power remaining the same in both cases. Comparing, now, this ratio of 130 to 100 with that of the time employed to travel respectively each canal, viz, 189 hours to 146, it is found that these ratios are equal. Therefore, on either of these canals, and notwithstanding a difference of 2,558 feet lockage, an equal weight will be transported during the same time, and with an equal towing power—a result entirely due to a larger transverse section having been assigned to the canal whose lockage is greater.

With a view to augment still more the amount of transportation without increasing the expense attending it, the boat might have received a length of at least eight times its breadth; but it would have required a length of lock of 118 feet, (between the hollow quoins,) which, on account of the great number of locks, would have caused too great an expense. The necessity of conciliating economy with the object to be expected from the work has, therefore, obliged us to limit the length of the boat to seven times its breadth, 13½ feet—it is to say, to 94 feet about; this length varying, however, from 90 to 94 feet, according to the mode of constructing the boat. With a draught of 3 feet, such a boat, if rectangular, would displace about 100 tons weight of water, or, on account of deviation from this form, about 90 tons only, it will carry a burden of 60 tons. Respecting the locks destined to admit this boat, they must have at least 102 feet between the hollow quoins, and 16 feet breadth in the clear. In the estimate, they are nearly all supposed to be of 8 feet lift, though in the framing of a final plan they should vary according to considerations not immediately connected with the object of the present report.

The sheet No. 3 exhibits the plan and sections of the lock upon which has been made the estimate of this article of expense. The main walls are built of common range-work masonry, (No. 18;) their facing only is laid with water-lime cement. Hewn stone has been used exclusively for the hollow quoins, mitre-sills, abutments, and recesses of gates. The blocks do not exceed 9 cubic feet, (Nos. 27 and 28.) The bottom of the chamber consists chiefly of a reversed arch, built of brick, with water-lime cement.

The estimate amounts to $13,069.80. But we must take into consideration that a number of locks will have their foundation upon solid rock, and will therefore require less masonry; and also that owing to the necessary declination, which, in the final plan, the bottom of the canal will receive, the amount of lockage will be less than it is in this general plan. Under these impressions, $12,000 has been deemed a fair average cost of a lock on the whole line of canal.

Respecting the aqueducts, they are to be built of masonry, and their lengths calculated to afford a free passage to the streams at the time of freshets; they are generally to be connected with the sides of the valley by means of embankments carefully made.

We now pass to the description of the canal.

EASTERN SECTION.

[Omitted.]

MIDDLE SECTION.

This section includes the summit-level and extends from Cumberland (or rather from the western end of the eastern section) to the mouth of Casselman's River, in the Youghiogheny. Its length is 70 miles 1,010 yards; but a lockage of 1961 feet and a tunnel of 4 miles 80 yards long, under a ridge of 856 feet elevation, will make this section extraordinarily expensive.

This section will, besides, require the erection of dams across the valleys through which it passes, and more especially in the bed of Will's Creek. This stream, in fact, affords, in summer and fall, a too small supply of water toward its sources to rely altogether upon it; the summit-level must feed, therefore, the upper portions, while frequent dams erected across the valley will make available the water delivered by the stream.

The valleys of Will's Creek and Casselman's River being formed of a succession of flats and bluffs, the canal will often require to be supported by walls whose height should place the work out of reach of the freshets. These freshets rise in Will's Creek from 7 to 10 feet, and from 12 to 16 feet in Casselman's.

In planning this section, care has been taken to avoid, as much as practicable, expensive aqueducts, and none is to be erected over Casselman's River. The canal will follow, constantly, the right side of the valley, whose southern exposure will procure

an earlier navigation in spring and later in autumn. Respecting Will's Creek, its valley is so narrow at some places and the height of freshets so inconsiderable, that four crossings have been made to take advantage of the most favorable ground, and thus lessen the expense. It must be observed that these two streams are not navigable, and will, therefore, require no peculiar work to accommodate their trade and navigation.

The execution of the tunnel will be not only very expensive, but also long and difficult; all the geological appearances lead to the conclusion that the excavation will have to be made through sandstone rock. The estimate has been calculated for three different kinds of ground; hard clay, sandstone, granite, and unstratified limestone. The hypothesis of sandstone being admitted here, the estimate relating to this kind of ground accompanies the present report. (See sheet No. 5.) The tunnel will require to be lined with masonry, experience having shown that this precaution is indispensable. Brick masonry has been adopted in the estimate as the most convenient to fulfill the object. The dimensions of the interior of the tunnel are, 22 feet in width, 7 feet under the water-line, and 16½ feet above the same line, which form 23½ feet from the bottom to the top of the arch. The tow-path is 4 feet wide. The shafts destined to facilitate the excavation, and to air the tunnel, are proposed to be sunk 180 yards apart from center to center. Their diameter will be 6 feet within the lining of brick masonry. A gallery, lateral and parallel to the tunnel, corresponds with the shafts. This gallery, or heading, is destined to drain the tunnel during its excavation; its width is 3 feet, and its height 6½ feet; it is lined with brick masonry, and communicates with the tunnel by means of arcades or side headings, which correspond to the points at which the shafts terminate into the heading. The sheet No. 4, herewith annexed, exhibits all the draughts relating to this tunnel, and to the deep cuts at its ends.

The deep cut at the western end is 1,060 yards long; that at the eastern 140 yards; each opens into a basin having 880 yards in length and 64 yards in width. The tunnel, the deep cuts, and the basins form together the summit-level, whose length will be 5 miles 1,280 yards; a lock is located at each end, and where each basin terminates.

Let us now examine the resources upon which we can rely to supply with water this summit-level, and the portions of canal contiguous to it. The stream upon which we have chiefly to depend is Casselman's; it yielded in 1825 and 1826 the following results:

	Cubic ft.
June 21, 1825, at Pleacher's farm, per second	18
July 10, 1825, below Flaugherty's Creek	38
July 12, 1826, at its mouth	46
March 12, 1826, at Pleacher's farm	98
March 27, 1826, below Flaugherty's Creek	715
March 21, 1826, at Forney's mill-dam	536

We have admitted, in the former part of the present report, 18 cubic feet per second as the minimum of water yielded by Casselman's River; and we have also pointed out two reservoirs, one at Pleacher's Farm and the other at Forney's Mill, containing together 22,000,000 cubic yards. These are the resources afforded by the localities to feed the summit-level and supply its lockage, and also portions of canal contiguous to the summit-level.

The reservoirs are to be filled in winter, during the interruption of the navigation—an interruption which, considering the elevation of the summit-level above the ocean, 1,903 (?) feet, cannot be supposed less than four months, viz: from the 1st of December to the 1st of April. By adopting 98 cubic feet per second as the mean-supply afforded in winter by Casselman's River, at Pleacher's farm, we find that in less than seventy-two days both reservoirs would be filled up.

However, to remove any doubt on the subject, we will take an area of thirty-six square miles of ground, whose rain-water supplies Casselman's River, and make a computation of what such an area would yield; we will suppose it to be formed of two strips of land, each of eighteen miles long and one mile wide, and stretching along the banks of Casselman's River above Forney's mill.

From observations made, from 1817 to 1824, inclusively, by Mr. Lewis Brantz, in the vicinity of Baltimore, we have the following results: In the course of these eight years there fell, on a mean average yearly, 39.89 inches of rain; in 1822, there fell the smallest quantity, which was 29.20 inches; the greatest quantity fell in 1817; it amounted to 48.55 inches.

Adopting these data for the country round the summit-level, and using the results of the year 1822, we find that the rain which fell in the three first and three last months of said year amounted to 16.70 inches, and for the six other months to 12½ inches.

	Cubic yards.
These 16.70 inches are equivalent per square-yard surface to	0. 463
The 12½ inches are equivalent per square-yard surface to	0. 347
The whole or 29.20 inches are equivalent per square-yard surface to	0. 810

Applying now these last results to the area of thirty-six square miles above mentioned, we find that they will receive at the minimum :

	Cubic yards.
During the fall and winter	51,630,796.80
During the spring and summer	38,695,219.20
The whole year round	90,326,016.00

From which it will be seen, first, that the two-thirds of the first quantity, or 34,420,531$\frac{2}{10}$ cubic yards, would be about one-third more than will be necessary to fill up the reservoirs in four months; second, that 44 cubic feet per second would make up, during six months, the two-thirds of the second quantity, and might, therefore, be deemed the mean-discharge, per second, of Casselman's River during spring and summer, instead of 18 cubic feet assumed in the present report; third, that this surplus will partly replenish the reservoirs during the time of navigation.

If to these considerations we add that, instead of thirty-six square miles, we might easily have taken double, we may conclude that, the filtrations and evaporations of rain-water being taken into the most liberal account, the portion of Casselman's Valley above Forney's mill will convey to the bed of this river more water than we have admitted; we believe, therefore, that the minimum supply of the summit-level will consist of, first, a reservoir of 22,000,000 cubic yards; second, eighteen cubic feet per second of running water. And, since the navigation is supposed to be opened during eight months, the monthly resources will be 2,750,000 cubic yards from the reservoirs, 1,728,000 cubic yards from the river itself; total 4,478,000 cubic yards per month. Let us see now how will be regulated the use of this monthly supply. Taking into consideration the unavoidable delays at the end of the summit-level, the impediments at the debouches of the tunnel and through the deep cuts, and, finally, the greater resistance the boats will meet through the tunnel, we cannot suppose less than 3 hours and 25 minutes for a boat to pass from one end of the summit-level to the other, which comes to one and two-thirds miles per hour. But the passage is to be effected in fleets or trains, on account of economy both of time and water; and we adopt thirty boats for each train, a number which in the present case seems to us favorable to combine the time of passage with the supply of water during the same time. These thirty boats, moving in train, will meet with more delay than would a single boat, and instead of 3 hours and 25 minutes, as before stated, we assign 4 hours to the train to pass from one end to the other of the summit-level.

We suppose, also, that a fleet of thirty boats, descending the eastern lock of the summit-level, and (through the same lock) passing an ascending fleet of the same number of boats, will effectuate this cross passage in eight hours, under the plausible supposition that 16 minutes will be required for the cross passage of a boat ascending and one descending. A similar cross passage is supposed to take place at the western lock of the summit-level, and at the same time.

Now, a first fleet leaving the eastern lock will arrive four hours afterward at the western lock, and meet there a fleet coming from the west, and ready to proceed eastward. This second fleet will reach in four hours the eastern lock, and find there a third fleet having ascended the lock during the passage of the first and second fleets. This third fleet will proceed westward, and arrive four hours after at the western lock, where it will find a fourth fleet, having ascended the lock during the passage of the second and third fleets. Lastly, this fourth fleet will move eastward and reach in four hours the eastern lock, meeting there with a fleet from the east, having ascended the eastern lock during the passage of the third and fourth fleet.

The passages of these four fleets forming together 120 boats, and requiring four hours each, may be considered, as will be seen just now, the maximum of trade which the supply of water can admit. At this rate of 120 boats a day, 3,600 might pass per month, and 28,800 during the eight months of open navigation.

Let us now compute the expanse of water which the lockage of these boats will require. Admitting, as in fact it will be the case, that, at each lock, one ascending boat alternates with a descending one, each boat will draw, from the summit-level, but one lockful, viz, half a lockful at each end. However, in order to provide for contingencies and unforeseen cases, we adopt one lockful and a half for the passage of each boat through the summit-level. One lockful and a half containing 623 cubic yards, the 3,600 boats passing during one month will require 2,242,800 cubic yards of water, which being taken out of the monthly supply, amounting to 4,478,000 cubic yards, will leave 2,235,200 cubic yards. This last quantity is destined to feed the canal itself, exclusive of lockage, on a length of 18 miles and at a rate of 120,000 cubic yards per mile and per month, absorption, filtration, and evaporation being taken into account. These eighteen miles comprehend the summit-level, a portion of six miles in Will s Creek, and a similar of also six miles in Casselman's Valley. The remainder of the canal down Will's Creek will be supplied by this stream, while Casselman's River will feed the remainder of the canal descending its valley.

The estimated cost of the summit-level, just described, is as follows:

The tunnel—

Shafts	$233,032 95
Heading	383,534 83
Side-heading	7,704 27
Tunnel	2,495,242 80
Draining	159,469 30
Total cost of tunnel	3,278,984 15
The eastern basin	26,741 14
The eastern deep-cut	18,733 00
The western deep-cut	141,840 72
The western basin	5,668 00
Total estimate of the summit-level	3,471,967 01

The details relating to the estimate of the tunnel are exhibited in the sheet No. 5, annexed to this report. As to the basins and deep cuts, their detailed estimates have been carried into those belonging to the eastern and western portions of this middle section. We shall now present successively the description of these portions: the eastern, commencing at the eastern end of the summit-level and terminating below Cumberland; the western, beginning at the western end of the summit-level, and debouching into the Youghiogheny below the mouth of Casselman's River.

EASTERN PORTION.

Subdivision 1.—From the eastern end of the summit-level to the mouth of Little Will's Creek:

Distance, 16 miles 460 yards; descent, 1,016 feet; 127 locks.

The canal follows for 8½ miles the left side of the valley of Will's Creek; it then crosses the stream to descend for two miles along the right bank; crossing again the creek it remains on the left side as far down as the fourteenth mile; it then crosses a third time, to follow the right side of the valley, as far down as opposite the mouth of Little Will's Creek.

The considerable descent in so short a distance, the contracted breadth of the valley, the steepness of its sides, the great quantity of excavation in rocky ground, will concur together to render this subdivision very expensive in proportion to its extent.

The distance between the heads of two consecutive locks will not be less than 180 yards. The first six miles will be fed, as stated before, by the summit-level; the remainder will be supplied by Will's Creek. To that effect dams, erected at suitable places, will afford the means of taking into the canal not only the waters of the creek, but also those of its tributaries.

The estimate of this subdivision amounts to (the eastern basin and deep cut excluded) $2,300,859.28.

Subdivision 2.—From the mouth of Little Will's Creek to the western end of the eastern section, below Cumberland:

Distance, 13¾ miles; descent, 309 feet; 39 locks. From the summit-level, 29 miles 240 yards; descent, 1,325 feet; 166 locks.

At the commencement of this subdivision, the line of canal takes a sudden change of direction from nearly east and west to almost north and south. The valley also changes its character, becoming broader, more level, and less rapid in its descent.

The canal continues for ten and one-half miles on the right bank of the stream, passing alternately along steep and rocky hill-sides, and through meadow-land, but even in the latter requiring a large quantity of excavation of rock. It then passes over to the left bank, and continues for more than half a mile on favorable ground, when it enters the defile formed by the breaking of Will's Creek through the mountain of the same name.

The difficulties of this passage are great, and continue for more than a mile. The ground then becomes favorable, permitting the canal to pass at the outskirts of Cumberland, to join with the eastern section.

Provision is made for taking in a supply of water immediately below the junction of Great and Little Will's Creeks, and also at several points below. Adjoining Cumberland, the canal will receive a feeder from the Potomac, for a supply below, and more especially to complete what is necessary in relation to the first subdivision of the eastern section.

This feeder is proposed to be made navigable, in order to accommodate the trade of the Potomac above Cumberland. Its length is one mile; its width, at the water-line, 30 feet; its depth, 4 feet. At its point of departure from the Potomac a basin formed in the bed of the river, by means of a dam erected at the first ledge above

Cumberland. This basin, comprehending an extent of about eight miles, will afford a constant supply of water, and also accommodate the coal trade of the Potomac. The levees around the basin, the dam, the guard-lock of the feeder, the feeder and its aqueduct over Will's Creek, are included in the estimate of this subdivision.

A basin is contemplated at Cumberland, and adapted to the probable wants of the place; it will be provided with locks to communicate with the Potomac.

The estimate of this subdivision amounts to $1,555,764.32. The estimate of the eastern portion amounts to $3,856,623.60.

WESTERN PORTION.

Subdivision 1.—From the western end of the summit-level to the mouth of Middle Fork Creek:

Distance, 16½ miles; descent, 216 feet; 27 locks.

This subdivision commences at the western end of the basin formed in the valley of Flaugherty's Creek, and into which is introduced the feeder from the reservoirs in the valley of Casselman's. Having already stated all the details relating to this appendage of the summit-level, we find ourselves dispensed from entering into further explanation upon the subject.

The canal for this subdivision is on the right bank of Casselman's River. On this distance, although no very formidable difficulties are presented, yet the amount of excavation of rock, as also the great quantity of walling, will render the work very expensive. The first six miles are to be fed by the summit-level, as it has been stated; as to the remainder, provision has been made, at several places, for taking from Casselman's River additional supplies.

It is to be observed that this upper subdivision of Casselman's River has a descent less rapid than that of the lower; the reverse takes place in the valley of Will's Creek.

The estimate of this subdivision amounts to (the western basin and deep cut excluded) $1,240,215.32.

Subdivision 2.—From the mouth of Middle Fork Creek to the mouth of Casselman's River:

Distance, 19 miles 1,030 yards; descent, 420 feet; 53 locks. From the western end of the summit-level, 35 miles 1,250 yards; descent, 636 feet; 80 locks.

This subdivision keeps on the right bank of Casselman's River, as far down as 440 yards below its mouth. The nature of the ground through which it passes resembles that of the subdivision above, except in the vicinity of the Youghiogheny, when it becomes much more favorable, offering more earth and less rock for excavation than above. Occasional resorts to the stream will secure to the canal a competent supply of water. And at the end of this subdivision, two feeders, one from Casselman's River and the other from Laurel Hill Run, are introduced for the supply of the section descending the valley of the Youghiogheny.

According to the documents hereto annexed, the estimate of this subdivision amounts to $1,459,316.93. And the estimate of the western portion amounts to $2,699,532.25.

We close the description of the present middle section by offering the following summary of the main facts relating to it:

	Distances.	Ascent and descent.	Number of locks.	Estimate.
	Miles. Yds.	*Feet.*		
Eastern portion	29 240	1,325	166	$3,856,623 60
Summit-level	5 1,280	....	....	8,471,967 01
Western portion	35 1,250	636	80	2,699,532 25
Total	70 1,010	1,961	246	10,028,122 86

WESTERN SECTION.

This section commences 440 yards below the junction of Casselman's River with the Youghiogheny; it follows the right side of the valley to the Monongahela, and hence to Pittsburgh, along the right bank of this stream.

The ground on the left of the Youghiogheny is nearly of the same kind as that on the right; the distance and descent the same for either bank; however, the right bank deserves the preference on account of exposure, and of its receiving the main tributaries of the stream; it will not require, across the Youghiogheny, two aqueducts, which would otherwise become indispensable, should the canal follow the left side of the valley.

This section will be supplied with water by the Youghiogheny and its tributaries; and since the eastern end must rely chiefly upon the Youghiogheny, Casselman's River, and

Laurel Hill Run, we will first present the results of the gauging of the streams, made in 1825 and 1826, during the month of July :

	Cubic feet.
Casselman's at its mouth, July 20, 1825, per second	40
Laurel Hill Run at its mouth, July 20, 1825	7
Youghiogheny River, above the mouth of Casselman s, July 21, 1825	70
Cubic feet per second	117
Casselman's at its mouth, July 20, 1826, per second	46
Laurel Hill at its mouth, July 20, 1826, per second	26
Youghiogheny River, above the mouth of Casselman's, July 20, 1826	104
Cubic feet per second	176

These results, though obtained at a time of low water, yet cannot be deemed as the minima of what these streams can afford; when measured they were not at their lowest stage. Therefore, we assume but 70 cubic feet per second as the minimum of water yielded by these three streams taken together, at the driest epoch of the year.

The Youghiogheny gauged at other points has given, in 1825, the following results :

July 28, at the Ohiopyle Falls, per second, 155 cubic feet reduced to 100 cubic feet.

August 2, at Connellsville, per second, 129 cubic feet reduced to 100 cubic feet.

September 2, at its mouth, per second, 200 cubic feet reduced to 150 cubic feet.

The stream, though very low when measured, was not, however, at its lowest stage; but the season was uncommonly dry, and the above reductions may be considered as minimum.

To these resources of running water we must add the following reservoirs:

	Cubic yards.
Indian Creek	210, 370
Mountz's Creek	323, 889
Jacob's Creek	356, 857
Big Sewickly Creek	1, 750, 180
Dunbar	214, 464
	2, 855, 760

To which may be added the reservoirs which might be formed in Casselman's River and Laurel Hill Run Valleys.

We must remark that the feeders from all these reservoirs will be very short, their length varying from half a mile to four miles only.

Having pointed out the means upon which we have full reliance to feed this section of canal, we shall show their distribution at the same time as we describe the successive subdivisions of said sections.

Subdivision 1.—From the western end of the middle section to Connellsville :

Distance, 27½ miles ; descent, 432 feet ; 54 locks.

This subdivision begins about one-quarter of a mile below the mouth of Casselman's River. The bottom of the canal is placed here 4 feet above the level of low water in Casselman's River, in order to afford the greatest advantage in taking a feeder from this stream, and also in using the most favorable ground below.

In the course of the first three miles, the ground becomes gradually more difficult, until it assumes the rocky and steep appearance which is so peculiarly the character of the Youghiogheny in so many parts of its upper course. To this difficulty of the ground must be added those arising from the necessity of keeping the canal above the freshets, whose elevation varies from 13 to 16 feet.

The ground continues unfavorable as far down as the old salt-works, seven miles from the beginning of this subdivision, where the line pursues, for a short distance, some favorable ground ; but it becomes almost immediately thrown upon a steep hillside covered with loose rocks, and which continues for three miles further to Ohiopyle Falls.

These falls form one of the most remarkable features of the Youghiogheny, and are formed by the river breaking through the rocky base of the ridge of Laurel Hill. The difficulty it has found in forcing this obstacle is plainly indicated by the sudden bend which the river here makes and the rough appearance of the channel it has carved out. It is most fortunate that the line of canal can, by means of a moderate cut, 283 yards long and 18½ feet deep, avoid pursuing the bank of this rugged channel. This deep cut across the neck of the bend of the river has, besides, the advantage of shortening the line by one mile and a half.

A feeder is proposed to be taken from the river a little above the falls, for which the localities are very favorable ; but the line of canal, by pursuing the most advantageous ground, has to descend, within the short distance of one mile, 96 feet; which circumstance will oblige to locate the locks too near to each other for presenting ponds of sufficient extent between them. Several plans suggested themselves to obviate this

inconvenience: first, to have the intervening ponds sufficiently wide to admit the easy passage of two boats at once, and to supply these ponds and the locks by means of a waste-way parallel to their course; second, to have lateral reservoirs to receive the contents of adjoining locks, and to transmit it respectively to the second lock below; third, to make the ponds liable to have the level of their waters varied from 2 to 3 feet, and thus making them perform the functions of locks. A close examination, when locating the line, will determine which of these means deserves the preference. The two first will cause a greater consumption of water than usual, but as a feeder, to be immediately introduced above for the purpose of supplying the next level below, this consumption is not, in this case, to be taken into consideration.

Below the Ohiopyle Falls the ground continues difficult for about nine miles to Indian Creek. On this distance the canal is mostly to be carried along a steep bank, in part supported by walls, and excavated through rock. The descent is also rapid, being about 160 feet, and requiring 20 locks. Indian Creek is to be crossed by an aqueduct; it will afford a valuable supply of water, for securing which a feeder and reservoir are proposed.

The ground from Indian Creek to Connellsville, seven miles, is still difficult, but more varied in its character than above; it will necessitate alternately steep hill-side cutting, much of which is rock, and some expensive walling, interspersed with some pieces of moderate cutting.

A basin is proposed at Connellsville, on the level of the canal, for the accommodation of the trade of this place; its communication with the river is established by means of locks.

This subdivision is supplied with water by the Youghiogheny above the mouth of Casselman's River, by Casselman's River and Laurel Hill Run. At the Ohiopyle Falls it receives a new supply from the Youghiogheny; at Indian Creek it will also, when necessary, receive a supply from the reservoir formed above the mouth of this creek. From the detailed estimate, hereto annexed, the estimate cost of this subdivision amounts to $1,515,436.59.

Subdivision 2.—From Connellsville to Sewickly Creek:

Distance, 27½ miles; descent, 144 feet; 18 locks. From the beginning of the section, 54¾ miles; descent, 576 feet; 72 locks.

Before arriving at Connellsville the line may be said to have completely passed the range of the western ridges, and the face of the country undergoes an entire change. The banks of the river, however, do not so suddenly lose the character they bear above, but it continues to offer a succession of similar, though gradually decreasing difficulties, for some distance below. This subdivision will, therefore, like the portion above Connellsville, require, for almost its whole distance, steep side-cutting and walling alternately; it will, consequently, be expensive.

Mountz's Creek, one mile, and Jacob's Creek, seventeen miles, below Connellsville, will afford a valuable supply of water for this subdivision; but a resort to the river is still considered necessary, and provision is made to effect this a little below Mountz's Creek.

The two creeks hereabove mentioned are to be crossed by aqueducts which, owing to the great breadth of the valleys, will require, at their ends, considerable embankments.

The estimated cost of this subdivision amounts to $1,306,525.95.

Subdivision 3.—From Sewickly Creek to the mouth of the Youghiogheny:

Distance, 16½ miles; descent, 8 feet; 1 lock. From the beginning of the section, 71¼ miles; descent, 584 feet; 73 locks.

This subdivision offers a larger portion of easy cutting than the preceding, but will still require a large portion of side-cutting and walls to pass round the bluffs. These subdivisions are numerous, and though none individually is of great extent, yet they form, together, a length of several miles of expensive works.

As McKeesport is at the junction of the Youghiogheny and Monongahela, a basin is proposed there for the accommodation of the trade of the latter stream.

The only lateral supply of water for this subdivision is from the reservoir above the mouth of Sewickly Creek, and it becomes necessary to resort to the Youghiogheny again in order to meet the deficiency which otherwise would be felt on the subdivision to Pittsburgh. To fulfill this object, a dam is proposed across the Youghiogheny at a favorable point three miles above its mouth. This dam will require a considerable height, and therefore locks must adjoin it that the navigation of the stream should not be injured by the works of the canal, but rather be benefited by them.

The estimate of this subdivision amounts to $741,469.54.

Subdivision 4.—From the mouth of the Youghiogheny to Pittsburgh:

Distance, 14 miles; descent, 35 feet; 5 locks. From the beginning of the section, 85¼ miles; descent, 619 feet; 78 locks.

This subdivision is generally located through favorable ground; however, some side excavation will still be necessary, and a deep cut near Pittsburgh of about three miles in length and 15 feet of average depth is indispensable to avoid a line yet more difficult and expensive.

This subdivision is almost entirely dependent on the Youghiogheny, above McKeesport, for its supply of water; the streams crossed by the canal afford so little water during the dry season that no reliance can be placed upon them.

According to the documents hereto annexed, the estimate of this subdivision amounts to $606,891.60.

Summary of the western section.

Distance.	Descent.	Number of locks.	Estimate.
Miles. 85¼	*Feet.* 619	78	$4,170,223 78

Here ends the description of the several sections of the Chesapeake and Ohio Canal, and whose general summary is as follows:

Sections.	Distance.		Ascent and descent.	Number of locks.	Amount of estimate.
	Miles.	*Yds.*	*Feet.*		
Eastern	185	1,078	578	74	$8,177,081 05
Middle	70	1,010	1,961	246	10,028,122 86
Western	85	348	619	78	4,170,223 78
Total	341	676	3,158	398	22,375,427 69

The foregoing description shows that the Chesapeake and Ohio Canal presents nearly all the characteristics which contribute to render a work of this kind very expensive, viz, an extraordinary amount of lockage, a long tunnel passing under a very elevated ridge; walling unusually frequent along the whole line; extensive portions of deep cutting; excavation of rocky ground and side cutting, predominating from one end of the canal to the other. The tunnel and lockage alone form, together, four-elevenths of the whole expense, and if, from the total estimate, we take out the tunnel, and reduce the lockage to 1,200 feet, (which may be deemed an unusual amount for such a distance,) the estimate would then amount to $16,000,000 only, notwithstanding the other difficulties to be overcome, and the accommodation of trade along the valleys of the Potomac and Youghiogheny.

We will also observe that the middle section alone, whose length is but seventy miles, or one-fifth of the whole length of the line, will cost (according to the estimate) $10,000,000, or the five-elevenths of the whole expense, while the eastern and western sections, whose lengths form together the four-fifths of the whole, will cost but $12,000,000, or the six-elevenths of the whole estimate.

We consider, however, as fortunate that these two expensive articles, extra lockage and tunnel, should be found both located upon a section which, after new investigations and mature reflection, might prove to be advantageously superseded by a railway. Indeed, the inexhaustible mines of coal found in the lower parts of the valleys of Will's Creek and Casselman's River seem to point out to us, as a means to avoid this expensive middle section, the expediency of a railway, with either locomotive-engines or stationary steam-engines, used as lifting-power.

We must also observe that this section will be wanted, but after the completion of the eastern and western sections, which two last being in Washington and Pittsburgh, within seventy miles of land communication, would soon point out, by their results, what should be the most expedient mode of connecting them. Perhaps, then, a smooth road, with an easy graduation, would, at first, be resorted to from the mouth of Casselman's River to Cumberland; or, should a great amount of trade warrant it, a railway might be adopted. In this latter case, which we deem the most probable, the revenue of the eastern and western sections would not only afford the usual interest of the capital employed in their construction, but also have a surplus fund with which a railway might be erected.

Therefore, we are decidedly of opinion that for the present the expense relating to the eastern and western sections ought exclusively to be taken into consideration; that the sum of about $12,000,000, to be expended for their construction, will create the means and afford the resources to procure to the work the mode of completion most adequate to its object.

Our instructions being to plan a canal from tide-water in the Potomac to the head of steamboat navigation in the Ohio River, we had not to take into consideration either railways or any other substitute for the difficult and expensive sections of the canal; therefore no operations in the field, no investigations in the closet, have been made in

relation to such an alternative. And, indeed, had even our instructions demanded such inquiries, the want of time and the limited means at our disposal would have prevented us from bestowing upon the subject the full and mature consideration to which it is so deservedly entitled. However, we do not hesitate anticipating that a railway from the mouth of Casselman's River to Cumberland will bear, as to expense and time, a favorable comparison with the middle section above described.

We recommend, therefore, for a canal from tide-water in the Potomac to the head of steamboat navigation in the Ohio the route and plan hereinabove described; and we submit respectfully to consideration the expediency of making the surveys and investigations necessary to ascertain, as accurately as practicable, the comparative merits of a railway and a canal for the section of route from Cumberland to the mouth of Casselman's River.

Additional subdivision of the eastern section of the Chesapeake and Ohio Canal from the mouth of Savage River to Cumberland.

Distance, 30 miles 350 yards; descent, 312 feet; 39 locks.

The canal for this subdivision remains on the left bank of the Potomac. This plan was adopted after an attentive consideration of the relative advantages and disadvantages of passing the river several times to follow the best ground. But to do this, such frequent crossings would be necessary, and attended with so many inconveniences and risks, that this project was deemed the less expedient.

As the object of this subdivision is to attain the coal mines near Savage River, it was considered whether this might not be attained by a canal of smaller dimensions and less perfect than the main line below; the result of which was that the dimensions and plan of the original canal were adhered to. For, first, it was found on applying the calculations to the ground, that a very trifling decrease of expense would be made by decreasing materially the dimensions of the canal; and, second, the unfavorable character of the river to a lock and dam navigation, which was thought of as a substitute, rendered this scheme almost as expensive, and much inferior in usefulness to the independent canal.

The subdivision begins by a basin formed in the Potomac by a dam, immediately below the mouth of Savage River. The line immediately enters on a most difficult piece of ground, which continues more than half a mile; another half mile is then favorable, after which it continues difficult for three-fourths of a mile, to Westernport. It then becomes favorable, with the exception of several small portions, to the end of the seventh mile, when the great bend of the river, opposite to Paddy Town, causes the ground to become very rugged and difficult for a space of two miles. Below this, for three miles, the favorable ground is intersected by only small portions of rock side. For the ensuing five miles, the approach of Fort Hill to the river presents alternately some easy ground, but a large portion of very difficult nature, requiring much walling and excavation of rock. Below this the ground is favorable for three miles, through Cressap's meadow, when difficulties again occur for two miles. The remaining distance to Cumberland is favorable with the exception of three portions, which are not of very great extent, but which will require extensive works. An aqueduct over Will's Creek will be necessary.

About eight miles above Cumberland it is proposed to place a dam across the river, and to use its water not only for the supply of the lower part of this subdivision, but also of that below.

BERNARD,
Member of the Board of Internal Improvement.
WM. TELL POUSSIN,
Captain Topographical Engineers, and Assistant to the Board.
W. HOWARD,
Civil Engineer, Assistant to the Board.

Abstract of estimate.

1,336,618 cubic yards excavation, (18 to 88 cents per yard)	$339,441 46
562,000 cubic yards embankment, (20 cents per yard)	113,257 60
210,931 cubic yards walling, ($3.50 per yard)	720,655 80
2 aqueducts, (3 arches and 2 arches)	66,277 00
41 locks of 800-foot lift, ($12,000 each)	492,000 00
34 culverts	10,200 00
12 bridges	4,200 00
Puddling	31,722 00
Fencing	16,200 00
2 waste-weirs	1,000 00
Total	1,794,963 86

Or 30⅕ miles, at $59,435 per mile.

APPENDIX B.

Report on the Salisbury Somerset Coal-Basin, by J. P. Lesley, Professor of Geology, University of Pennsylvania.

Somerset County, in southwest Pennsylvania, borders on Maryland.

Salisbury and Berlin are towns in its first sub-coal-basin back of the Alleghany Mountains; Ursina and Confluence are in the next sub-basin west of Negro Mountain; Ligonier Valley holds the second bituminous coal-basin, and lies west of Laurel Hill.

Connellsville and Blairsville, west of Chestnut Ridge, mark the east outcrop of the third, fourth, fifth, and sixth bituminous-coal basins, extending unbroken into the State of Ohio.

* * * * * * *

The basin of the upper or Salisbury coals extends about nine miles, from near Meyer's mills, at its north end, to just over the Maryland line.

The lower coal-beds, with which we will have less to do, spread down from the top of the Alleghany Mountains under the whole of Somerset County, excepting only the summit of Negro Mountain and the crest of Laurel Hill.

The upper coal-beds, which give to the Salisbury Basin its exceptional importance, have been entirely swept away from the surface of Somerset County, except in two places: 1st, they remain in the long narrow ridge at Salisbury; 2d, they remain in the central part of the Frostburgh or Cumberland Basin. They remain also in eastern Fayette County, in one little hill-top near Ligonier; and the Pittsburgh bed has been left in like manner, on Broad Top, in Huntingdon County, under a few acres at the summit of the highest peak of that mountain. With these few exceptions, this bed has been washed, worn, or eroded from the whole surface of Middle and Western Pennsylvania, east of a line drawn through Connellsville and Blairsville. West of this line, and south of the Kishkaminitas and Ohio Rivers, the upper or Pittsburgh coal series of beds have more or less escaped erosion, and are spread through western Fayette and Westmoreland Counties, and are mined everywhere along the rivers which flow with and into the Monongahela. At Ursina and Confluence we have only the lower coals. At Connellsville, Greensburgh, and Pittsburgh we have the upper coals, as also in the Salisbury Hills; also in the center of the Cumberland, George's Creek, or Frostburgh coal-basin. The "Pittsburgh Bed," the "Connellsville Bed," the "Irwin Gas-Coal Bed," the "Greensburgh Great Bed," the big bed at Latrobe and Saltsburgh, are all one and the same coal-bed; the same as the lowest of the three upper Salisbury beds, (about to be described,) the same as the George's Creek bed in the middle of the "Cumberland Basin."

This is the fact of first importance in a report on the Salisbury coal-basin.

The fact of next importance is that the coal-bed above described becomes thin and poor toward Pittsburgh and down the Ohio, but grows slowly and steadily in size and quality going east along the Pennsylvania Railroad, southeast along the Baltimore and Pittsburgh Railroad, and south up the Monongahela.

At Pittsburgh it is about 6 feet thick, and injured by pyrites and slate; at Irwin's and Monongahela City it is 8 and 9 feet thick, and a fine gas-coal; at Connellsville and Latrobe it is 11 and 12 feet thick, a noble bed for coking-purposes. What it was in the country between Connellsville and Meyer's mills we do not know, but when we next meet a fragment of it at Meyer's mills, in the Salisbury ridge, we find it from 12 to 15 feet thick. And finally, in the Cumberland Basin it is 17 feet thick, and everybody knows its quality there by the annual consumption of from one to two millions of tons in Baltimore, Philadelphia, New York, and Washington, and on coastwise and ocean steamers. This is the bed which furnishes almost all the coke used at Pittsburgh and the largest part of the raw coal of the Ohio-River trade, and its quality is so superior that it has long monopolized the iron-making market at Saint Louis, Mo. This is the bed which furnishes almost all the coal to the gas-works of the seaboard cities and inland towns; and apropos of this circumstance—

The fact of next importance is that the percentage of gas yielded by the coal of this bed increases westward and decreases eastward. In the Pittsburgh region it yields from 35 to 40 per cent. of volatile matter; at Blairsville, Latrobe, Connellsville, and Uniontown its average may be called 30 per cent.; in the Cumberland Basin it is sometimes as low as 17 per cent. Its average in the Salisbury Basin will, therefore, be somewhere above 20 per cent. and below 25 per cent.

(NOTE.—I have no trustworthy analysis of these Salisbury coals. One specimen was said to yield 29 per cent. volatile matter. The Ursina, Confluence, or Turkeyfoot lower coals under-run 29 per cent., and lie farther west.)

As we distinguish such coals as semi-bituminous, coals with only 10 to 12 per cent. as semi-anthracite, and coal with from 9 to 5 per cent. as anthracite, we may say (in the market) that the Salisbury coal (of this bed) belongs with the George's Creek Cumberland semi-bituminous steam-coals, the finest steam-coal, by the by, in the world. It has, however, a little more gas, and belongs properly also to the good coking-coals, with an advantage over the Connellsville part of the bed, not in the excellence of its

coke, but in making 200 pounds more of coke from a ton of coal, viz, 10 per cent., or whatever else may be the proved difference between the average percentage of volatile matter in the coals of the two districts.

The next important fact to be noticed is that there are three other coal-beds overlying the Pittsburgh-Connellsville bed, two of which are also preserved in the Salisbury Basin.

On Cheat River, in Virginia, the whole system of four beds is as follows:

	Feet.
Waynesburgh coal-bed, from	6 to 9
Interval, (shales, sandstones, limestone,) from	183 to 207
Sewickly coal-bed, from	4½ to 6
Interval, (shales, sandstone, limestone,) from	40 to 49
Redstone coal-bed, from	4 to 5
Interval, (shales, sandstone, limestone,) from	18 to 6
Pittsburgh coal-bed, from	7 to 14

At Uniontown and Connellsville there are, in all, six beds, well marked, and separated from each other; thus:

	Feet.
Nameless coal-bed	—
Interval	18
Waynesburgh coal-bed	1 to 3
Interval	120
Uniontown coal-bed	2
Interval (great limestone formation)	130
Sewickly coal-bed, interval	5
Redstone coal-bed, very thin, interval	86
Pittsburgh coal-bed	14

In our Salisbury coal-basin we have as the highest rock on the hill-tops, the equivalent of the Waynesburgh sandstone in the form of a massive conglomerate sandstone called (after its Kentucky name) the anvil-rock—black slate representing the Waynesburgh coal-bed.

	Feet.
The upper limestone, black slate, and a little coal	20
Uniontown coal-bed, (coal and slate)	50
The lower limestone	15
Sewickly coal, (upper Berlin, coal and slate)	15
Interval	55
Redstone coal, (double bed)	10
Interval	30
Pittsburgh coal, (lower Berlin)	11

Such was the section I made at Myer's mills, in September, 1857. In 1870 I got numerous sections along the southern or Salisbury portion of the basin, which show the usual variations both in the size of the coal-beds and in the intervals separating them, but prove the only fact of importance to us, that the Pittsburgh bed maintains its predominant quantity and quality the entire length of the basin. They prove also the Sewickly bed is everywhere large, but not reliable in quality, being very slaty. They prove also that the redstone-bed is persistent, but not an unusually large bed. They reveal, moreover, a new and important fact, that there is a valuable coal-bed underlying the Pittsburgh coal-bed.

The section of the southern half of the Salisbury basin (upper) coal-measures may, therefore, be thus stated:

	Feet.
The great limestone Sewickly coal-bed, (slaty)	10
Interval, (soft shales)	44
Redstone coal-bed	6
Interval, (shales)	10
Pittsburgh coal-bed, (with parting 2 feet)	18
Interval containing two small coal-beds	64
Salisbury coal-bed, over	4
Thence down to the level of Casselman's River	55

(Opened recently on the Jonas Beechy tract, 15 feet above river, 5½ feet of pure coal.)

Although the Salisbury basin is only nine or ten miles long, and one or two miles wide, and cut by numerous short ravines, which make the outcrop of these beds follow zigzag courses around the hill-sides, it will be seen at once, from the above sections, what an enormous quantity of coal has been left in the ridge, and how perfectly accessible it is. I shall give quantities presently.

There lie beneath the river-bed, and conformable to the upper coal-measures just

described, the following beds of the lower coal-measures. These have been struck in an oil-well boring as follows in depths from mouth of well:

	Feet.
Elk Lick coal, (called 4 feet thick,) at	96
Upper Freeport coal, (called 10 feet thick,) at	132
Lower Freeport (?) coal, (called 8 feet,) at	252
Black slate and coal, (mixed, 2 feet,) at	300
Johnstown ore-bed, at about	340
Streaks of coal, at about	480
Conglomerate, (forming crest of Alleghany Mountains)	500
And continuing more or less to	640
Red shale of XI, hence down to bottom of well	690

These coal-beds of the lower system spread through the hills east of Casselman's River, and from the mineral riches of all the Berlin, Salisbury, Ursina, and Johnstown country; but they are hardly worthy of entering into our present discussion of the upper coal-beds of the Pittsburgh (Salisbury) series, in the Salisbury Basin ridge.

The area occupied by the Pittsburgh (Connellsville or Westmoreland) bed is eight and a half miles long; its greatest width is three miles, and the average width opposite Salisbury, and south of Tubmill Run, one mile.

QUANTITY OF PITTSBURGH BED-COAL.

The sum total of 5,000 acres of coal-bed is got by deducting about 1,000 acres for loss by valley erosion, and indefinite southwest limit, from 5,955 acres of calculated total coal-bed area between Myer's mills and the south end of the Salisbury Basin.

The whole area is subdivided naturally into four portions, thus:

		Per foot.
A	2 000 acres, which at 1,000 tons	2,000,000 tons.
B	2,200 acres, which at 1,000 tons	2,200,000 tons.
C	915 acres, which at 1,000 tons	915,000 tons.
D	840 acres, which at 1,000 tons	840,000 tons.
	5,955 acres, which at 1,000 tons	5,955,000 tons.
Say 5,000		5,000,000 tons.
Allowing only 10 feet depth to the bed we get		50,000,000 tons.

NOTE.—The above estimate of 1,000 tons to the acre, for each foot thickness of bed, allows for pillars, slack and waste of all kinds, and represents the amount of coal placed in the cars outside.

The actual geological quantity of coal in this Salisbury (Somerset County) outlier of the great Pittsburgh bed, must be nearly one hundred millions of tons.

QUANTITY OF REDSTONE BED-COAL.

The area of this bed is about one-half that of the great bed below it, and its average thickness is not so well known. I do not think it prudent to estimate for all its detached areas, ten in number, more than 15,000,000 tons, possibly gross contents 24,000,000 tons.

QUANTITY OF SEWICKLY BED-COAL.

Area about one-tenth of the Pittsburgh bed; total of cost of all qualities, 5,000,000 tons. The above estimates are *in minimo*.

QUANTITY OF SALISBURY COAL.

The recent opening of this bed, 5½ feet thick, at an elevation a few yards above the river-level, near the south end of the basin, is a matter of great importance. The coal shown to me in Philadelphia is of superb quality, although somewhat too prismatic to bear long transport. It appears to be as pure as the best George's Creek (Cumberland) coal, and must make first quality of coke. (See analysis at end of this report.) It outcrops all along the river-face on both sides of Tubmill Run; and its total area must be at least one-half greater than that of the Pittsburgh bed, but I have reason to believe its thickness to be less at the north end than at the south end of the basin. (On Elk Lick Creek is a 4-foot bed of very good coal, but belonging to a lower geological position.)

The Salisbury coal-bed, if even 5 feet thick under the south end of the basin, will contain 25,000,000 tons, the most, if not all, of which lies above water-level. It is then proper to add to the above quantities a total available sum in this Salisbury bed of at least 20,000,000 tons.

QUANTITY OF COAL BENEATH WATER-LEVEL.

Future mining operations in the beds of the lower coal-measures will reveal their condition, thickness, and quantity. They underlie the whole area of, say, 9,000 acres, more or less, which is in question. It is perfectly safe to give two beds yielding 5 feet each, *i. e.*, to say, 120,000,000 tons, or on a practical estimate, 90,000,000 tons.

As these lower beds can only be reached by shafts, and as they spread throughout Somerset County, and the upper beds are above water-level and monopolized by a few properties between Meyer's mills and the Maryland line, it seems hardly worth while to introduce this secondary element into my estimate of the value of the Salisbury Basin, which is in itself, and entirely apart from the existence of these lower coal-beds, so extraordinarily valuable.

NOTE.—In any other coal-region of the world the existence of beds nearly horizontal, and to be reached by shafts less than 300 feet in depth, (see oil-well boring,) would of itself give great value to the overlying properties. My report on the Ursina lands shows that one bed struck by such a shaft is the fine 6-foot coal mined on the north fork of Casselman's River, on the west side of the Somerset Basin. Its analysis is a good deal like that of the Cumberland coal. This 6-feet bed is the great bed of Casselman's River, between Meyer's mills, Confluence, and Ursina, and it is increasing in thickness eastward, so that the report of its being 10 feet thick under Salisbury (see oil-well boring) may very well be a true one.

I first became acquainted with the isolated and exceptional character of this bed in 1840, during my survey of Somerset, Fayette, and Cambria Counties, in company with James F. Hodge, and as assistant of the State geologist, in whose fifth annual report my sketch of the geology of the Salisbury Basin is embodied, but without details. My knowledge of its peculiarities was much enlarged in subsequent years, and impressed me always more and more. I have frequently urged its claim to special attention, but until the completion of the Connellsville and Cumberland Railroad connection no steps for its development could be profitably undertaken. This connection being now made nothing can prevent this Salisbury Basin from becoming a second, though somewhat smaller, Cumberland Basin, and that without any rival but the Cumberland Basin.

(No. 1.)—For the little hill-top patch of Pittsburgh bed left standing in the Ligonier Valley is entirely out of the way of all trade, and too minute in itself to be of any account; and the Broad Top coals are those of the lower coal-system, small beds and subdivided, hence coming to market in a soft and dirty condition.

The Salisbury upper (Pittsburgh) coals, if coked, can go down to Pittsburgh in competition with the Connellsville upper (Pittsburgh) coal, coked; but the Connellsville coal, raw, is too bituminous to come eastward to Baltimore and Philadelphia in competition with the Salisbury and Cumberland coals, raw. These, then, compete with eacoh ther, but without competition from any other quarter whatever, forming virtuallytwo competing but allied monopolies of the best steam-coal known.

To feel the full force of this remark it must be kept in mind that what is called *par excellence* "Cumberland coal" comes from the "Big Bed," (George's Creek Bed, Pittsburgh Bed,) in the center of the Cumberland Basin, and what will soon be equally famous as "Salisbury coal" will come from the same Big Bed, Pittsburgh Bed, in the central ridge of the First Somerset or Salisbury Basin.

In considering the commercial value of these coal-beds in comparison with each other and the transportation distances by the many existing and proposed new routes to the eastern markets, it is to be borne in mind that the two coals, the Salisbury and Cumberland, come from one and the same (Pittsburgh, Connellsville, George's Creek) upper-coal series Great Coal Basin, and are of equal purity and the beds of equal size, or rather of greater size at Salisbury.

It is especially to be remembered that the Irwin coal (Westmoreland) is only to be used for gas-making purposes, and can only be brought eastward for those purposes; for coking purposes it must go to Pittsburgh and down the Ohio. Whereas the Salisbury coal will rival the Cumberland coal on a footing of equality, as the best steam-coal known, and have nothing but the Cumberland coal to compete with; for the Broad-top and Alleghany Mountain steam-coals all come from the smaller, more slaty, and softer beds of the lower coal system, and therefore always must be of inferior value in the market to the Cumberland and Salisbury coals; while on the other hand the Salisbury coal will coke admirably also, and command an equal standing in the Pittsburgh and down-Ohio-River markets.

Observing, finally, that the noble coals of Jefferson and West Clearfield, about to enter the seaboard markets on the completion of the Low Grade Railroad, must travel three hundred and twenty miles to reach Philadelphia, and then come into the seaboard market in competition with the Irwin gas-coal kinds, (transported three hundred and thirty-two miles,) to which they really belong, (although the beds are the upper beds of the lower coal system,) and cannot, therefore, compete well with steam-coals.

Considering all these points, I think I have justified the very exceptionable value which I have for many years past attached to the Salisbury coal-basin.

NOTE.—Analysis referred to:

Analysis of the five-foot Salisbury bed, mentioned in this report, made by Booth & Garrett.

Gas	16.02	Volatile matter	25.75
Tarry matter and water	9.73		
Fixed carbon	68.40	Coke	74.25
Ash	5.85		
			100.00

NOTE.—Assuming the specific gravity of the gas to be 0.45 compared with air as unity, the amount of gas yielded by one pound of coal will be 4.64 cubic feet. This analysis shows, first, the resemblance of this coal to the Cumberland; second, the great amount of coke it will produce even after a certain loss of fixed carbon.

APPENDIX C.

Letter of Mr. B. H. Latrobe.

BALTIMORE, *March* 2, 1874.

DEAR SIR: Upon my return home yesterday I received your letter of the 26th February, asking for information in regard to the cost of the Sand-Patch tunnel upon the line of the Pittsburgh and Connellsville Railroad.

The work on this tunnel, of 4,800 feet in length, was commenced and carried on for a couple of years or more prior to my connection with the road, and I am not now able to say from sources within my reach what it cost during that time. It was resumed in 1865, after a suspension of about eight years, and within the next two years the sum of $31,549 was expended in removing 7,620 cubic yards, at an average cost of $4.14 per cubic yard. This work was done by the day under the superintendence of an agent of the company, an experienced and trustworthy person, formerly and since a contractor upon the line. It gives therefore a pretty good criterion of actual cost without profit, although if done by contract the net cost might have been somewhat less, the desire to make a profit affording, even to an honest man, an additional incentive to economy.

There was 350 feet linear of heading and 500 feet of bottoming in the 7,620 cubic yards, the former constituting about one-third and the latter two-thirds of the whole sectional area of the tunnel, which was 16 feet wide by 18½ feet high, with semicircular roof where masonry was not required, with 2 to 3 feet additional width and height where lining was needed. The lining was of stone, as no good brick-clay was found in the neighborhood, and very good sandstone abounded in the large bowlders of the conglomerate rock which were found strewn over the surface in the vicinity.

The employment of this stone permitted the arch to be reduced from 18 inches (had it been of brick) to 12 inches in thickness, which sufficed for so moderate a span, the space over the arch not requiring more than 2 or 3 feet of packing, except at certain points where the rock had fallen more from overhead. The strata were inclined crosswise to the line of the tunnel, the dip being 40° or 50°, and the strike being nearly parallel to the axis of the tunnel, the grade ascending 1 in 100 from east to west, and the rock consisting of the old red sandstone underlying the coal-measures. A long canal-tunnel would cut across the stratification and encounter the lower coal-measures after passing through the old red and the mountain limestone and the millstone grit. After the final resumption of the work on the Sand-Patch tunnel in 1868, it was let to contractors, at the following prices:

Heading, what remained, (748 cubic yards,) nearly all being removed under previous contract	$7 per cubic yard.
Bottoming, what remained, (27,725 cubic yards)	$2.95 per cubic yard.
Stone packing over arch, (5,085 cubic yards)	$2.25 per cubic yard.
Side walls, stone masonry, (374 perches of 25 cubic feet)	$12.00
Arch, stone masonry, (1,899 perches of 25 cubic feet)	13.25

The railroad company furnished cement and sand, costing about $1 per perch, to be added to these prices.

The tunnel and approach-cuts, which were long, were made passable by trains in March, 1871; and since, some extension of the arching has been made, so that now about half the whole length, I think, is lined.

Since writing the above I have found some papers which give the prices of the first contract, made in 1853, viz: Heading, $5.25; bottom, $2; packing over arch, $2; shafts, (four in number, and 88, 120, 142, and 178 feet deep, respectively,) $6 per cubic yard. These were sunk before I took charge of the work. The first contractors abandoned the work, the prices being inadequate even at that day of lower prices of everything. The last contractors made a small profit by close management. The whole tunnel and approaches have cost about $420,000.

I should think it very unsafe to assume the preceding prices in estimating the cost of a long canal-tunnel, which might readily be 100 per cent. higher, and, for the shafts, three or four times as high.

The Sand-Patch tunnel was remarkably free from trouble with water, the rock of alternately hard and soft ledges, unfit for masonry, and much of it decomposing when exposed to the atmosphere.

I am, dear sir, respectfully yours,

BENJ. H. LATROBE.

Col. W. E. MERRILL,
United States Engineer Office,
No. 4 Public Landing, Cincinnati.